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INCENTIVES IN INDUSTRY

SINCE the late Samuel Courtauld's paper on government and industry was published in the *Economic Journal* in April 1942, the question of the relations between industry and government has steadily grown in importance. It is now widely realized that this question is bound up with that of the relation of industry as a whole with society, and of the internal relations of employers and employed, whether managers or operatives. Increasing concern with management and attempts to raise its standard in industry have emphasized the complexity of these relations and inter-relations, as has experience with the nationalized industries and the new public boards which have been brought into being in Great Britain. With all these questions the papers collected under the title "Ideals and Industry"* are concerned, and in the six or seven years since they were first delivered they have lost nothing of their force. They are as relevant to our immediate problems as to the conditions obtaining during the war years when they were prepared; industrial relations are at the root of the problem of securing the greater efficiency and higher productivity on which Britain's economic recovery depends, whether we think primarily of the external relations with government or the internal relations of man with man. Co-operation with, and in, industry should be our first concern; and at bottom the issue is one of human relations and of human understanding.

The re-appearance of these papers is to be welcomed for the emphasis they place on that specific point. Whether Mr. Courtauld is discussing government and industry, industrial relationships, industrial changes, labour management, the control of industry or co-operation, the deep respect which he shows for men and women as human beings and his sense of the responsibility of each man in society is manifest. That is well brought out also in the discerning appreciation which Mr. Charles Morgan contributes by way of preface. Indeed, it is not too much to say that the recovery of Britain will depend largely on the measure in which we can evoke that sense of personal responsibility from every citizen, whatever his occupation; and when that sense of responsibility is kindled, respect for human individuality becomes implicit.

Already hard experience of the past few years should have driven home the lesson even to the most doctrinaire mind that organisation by itself is not enough. To a large extent, the community favoured the nationalization of the coal industry of Britain in the belief that under national ownership a new outlook and a new sense of responsibility would be brought into it. It can no longer be held that nationalization by itself automatically establishes the right human relations within an industry, and secures the co-operation upon which efficiency and productivity depend. So far, the nationalized industries in Britain have proved no more successful than private industry in securing such co-operation and

* Ideals and Industry: War-time Papers. By the late Samuel Courtauld. Pp. xviii+134. (Cambridge: At the University Press, 1949.) 10s. 6d. net.

goodwill, and in such respects have been far behind some individual large and small firms.

At the outset of his paper on "Government and Industry", Mr. Courtauld made six assumptions. The experience of the past seven years has clearly justified the first five, and few unprejudiced observers will be disposed to dissent from his sixth—that the English genius for social evolution and for compromise can find a middle way, between pure individualism and pure socialism, which will bring the greatest attainable good to the nation. Indeed, it might be said that such a middle way offers, in Britain, the only hope of obtaining the higher productivity and efficiency which alone can solve the economic problems of the country. Production is still the most vital activity of the nation, government control remains and will increasingly determine industrial growth, labour may increasingly share in the management policy and rewards of industry, gambling in industrial counters may be ruthlessly eliminated and government bureaucracy no longer hinder the efficient conduct of business; but still the problem of securing the willing co-operation of all in that attempt to raise standards has to be solved.

In these pages are many suggestions which hitherto have not been explored. Much stress was laid by Mr. Courtauld on education; but little has yet been done on the lines he suggests. On the part of the Government, there has been but a partial recognition of the truth stated so plainly by Mr. Courtauld that, to work well, a man must take a real interest in his job and feel that he has full scope for his brains and abilities; that he must understand how his particular task fits into the whole manufacturing programme and that his ideas about it will be listened to and examined. Mr. Courtauld saw all the implications of this truth and just how it bears on the vital problem of incentives and on the work of works councils and production committees.

Mr. Courtauld's statement as to the main functions of government in relation to industry is worth recalling to-day. Government, he writes, should give general guidance, under the highest possible disinterested scientific and economic advice, to industrial development, in accordance with national interests. It should ensure that industry takes no measures to impede the development of new ideas, even if they threaten legitimate existing interests, except by order of the Government itself and under government safeguards. It should see that the law is kept in the spirit as well as in the letter, and should collect all statistics needed from the whole of industry, and keep an open clearing-house of information. In particular, Mr. Courtauld emphasized that the State should have a far-reaching control over the location of industry and over its intake of labour, so as to prevent the recruitment of juveniles into blind-alley occupations. He set his face against commercial education; and he has wise words on taxation policy, and the danger of a policy which discourages men from developing and exploiting their own new ideas and devoting their own financial resources to doing so.

The present Government in Britain is manifestly in accord with some of Mr. Courtauld's ideals. Nothing could be more emphatic than Sir Stafford Cripps's and Mr. Attlee's words on the fundamental importance of production. The value of joint consultation has been established by experience, and the Minister of Labour has indicated the Government's desire to give every encouragement to industries to adopt the form of organisation for that purpose best suited to their particular needs. Steps have also been taken towards the provision of statistics, and though the Government has declined to adopt the essential recommendations of the Barlow Report as regards the location of industry, steps have been taken in that direction as well as in the field of education.

Nevertheless, the Government's relations with industry have been excessively rigid and marked by little realization that the main problem is that of creating and maintaining the attitude of co-operation which is the foundation of all successful industrial enterprise. The Government appears still to be indifferent alike to the fact that, while both the controls necessitated by war-time and post-war exigencies in regard to materials and high taxation have largely sapped the incentives to enterprise on the part of business men or managers, the advent of the welfare State and the policy of full employment have similarly undermined incentives on the part of those employed in industry, and that a high income tax and profits tax have tended in the same direction. Nor has sufficient regard been had to the way in which limitations on capital expenditure have handicapped the re-equipment of British industry; or to the further handicap imposed by the steady deterioration of communications such as postal services and railway services as compared with those obtaining fifty years ago.

More efficient management will certainly make an important contribution to increased productivity and the more effective use of our resources in man-power and materials. Unless, however, it is remembered at this juncture that the effect of the efforts of the British Management Institute, the Administrative Staff College and other bodies endeavouring to raise the standard of management and to investigate problems of management is severely circumscribed by the policy of the Government itself, there is real danger that the whole scientific approach to such matters will be discredited. Furthermore, leaving purely political considerations entirely on one side, the adequacy of the whole administrative organisation of the central government is open to challenge. The concern already manifested in Parliament, independent of party, as to the means for securing effective Parliamentary and public control over the nationalized industries and the public corporations is only one aspect of a problem to which Political and Economic Planning and other bodies have already turned their attention. Moreover, the extent to which personal freedom and the rights of individual citizens are being made subservient to administrative convenience is a further reason for expediting an overhaul of the whole structure of government, since this

also indirectly affects—and adversely—the attitude of the individual to production.

The whole question of the relations of government and industry should be re-examined outside the heat of party politics, so as to afford the nation an unprejudiced view as to the exact means by which Parliament could control the strategy of the nationalized industries and of the public corporations without that detailed interference which would cause a paralysing centralization. Time is an essential factor, for the overloading of Parliament and the Civil Service with legislative proposals is one reason for the present strain on the organisation of government and the cumulative threats to personal liberties. Whatever solution is found, whether the select committee, served by an appropriate staff, as the past experience of the House of Commons suggests, or any other method, it is of vital importance that besides technical efficiency, enterprise and constructive rather than restrictive policies should be stimulated.

A major charge to be laid against the Government's industrial policy is that it has inhibited enterprise and killed incentive, for the employer and manager and for the worker. The major charge which has to be preferred against the bulk of British industry, employer and employee alike, is that they have sought refuge in restrictions rather than in enterprise. The evidence of the report of the first team from a British industry—the steel foundry trade—sent to the United States by the Anglo-American Productivity Council is conclusive on this point. Much of this report is addressed to the steel foundry trade itself, but when it deals with the question of the factors that are responsible for higher productivity of the American industry and the part played by incentives, it touches on issues that have a bearing on almost every section of British industry. The report stresses the widespread "productivity consciousness" in the United States—the recognition that high productivity is a benefit to all concerned—and that in the background is the compulsion of competitiveness and the persistent endeavour to reach higher standards of living. The report suggests that Great Britain has been unmindful of the dangers attending the pursuit of freedom from want, of the corollary of a full employment policy, namely, mobility of labour, of which Gertrude Williams wrote so pointedly in her book "The Price of Social Security". The sixteen members of this team, in which management, technical staffs and craftsmen from eleven leading British steel foundries were represented, concluded that their industry and, by implication, other British industries, have drifted into a dangerous position from which they can be saved only if some of the most cherished traditions are broken down. If the right attitude to productivity is to become effective, the practices of all the collective organisations of industry—the trade associations, the employers' wage-negotiating bodies and the trade unions—will have to be changed.

This aspect of problems of production must be given more consideration at the present moment. Economies of various kinds, however right in themselves, cannot exert their proper effect unless attention is given to this question of incentives. We cannot wait while further research is made into new forms of joint consultation, the attitudes of groups and the evolution of more effective means of co-operation. The contribution which industrial psychology and the study of human relations in industry can make will not be diminished but rather enhanced when it is recognized plainly that fear and self-interest still powerfully condition men's minds and spur them to greater endeavour. Government policy should seek so to shape the conditions of industry and the relations of industry with the State by taxation and policy, economic and social, and its system of control, that by stimulating enterprise and initiative and discouraging restriction of every kind, the powerful forces to which this report bears witness are turned to serve the national interest as well as that of individuals.

APIOLE AND ESSENCE

The Essential Oils

By Dr. Ernest Guenther. Vol. 2: The Constituents of Essential Oils. Co-Author, Dr. Darrell Althausen. Pp. xiii+852. (New York: D. Van Nostrand Co., Inc.; London: Macmillan and Co., Ltd., 1949.) 75*s*. net.

IN this second volume, which follows close upon its predecessor (see *Nature*, **163**, 663; 1949), the constitution, occurrence, isolation and properties of several hundred compounds are discussed and documented with a precision and thoroughness (covering the literature up to 1948, inclusive) which leaves little room for comment. Each compound has a separate monograph, and there is an exhaustive subject-index. Dr. Frances Sterrett contributes a sixty-page appendix on the technique of preparing characteristic derivatives of the eight or nine chemical classes which comprise most of the compounds described.

Each monograph includes also a sub-head on uses. On direct uses in the perfume and flavour industries, the information of responsible agents of the firm of Fritzsche Brothers is, of course, authoritative. Beyond this, however, the authors do not seem always quite clear as to their terms of reference. If the large-scale use of palmitic and stearic acids in soap and cosmetics is considered relevant to the monographs recording the exiguous occurrence of those acids in essential oils, it is not easy to see why the large-scale use of styrene and camphor in plastics, or cymene as a solvent, should be omitted when those compounds are dealt with. Uses in which one essential-oil constituent serves as raw material for making another of greater value (citronellal for *l*-menthol, for example) are scarcely mentioned. Medicinal uses are more systematically recorded; there is a slight slip in attributing the name 'apiole' not only to the pure chemical, but also to the medicinal oil fraction which is properly distinguished as 'apiol'. And is it captious to suggest that, English idiom being what it is, the remark that "hydrocyanic acid cannot be used in any proportion in flavours" is less unambiguous than might be wished?

Although the authors modestly offer the work merely to lighten the labours of the essential-oils

chemist, it is certain to find wide use among many not directly concerned with the essential-oils industry; and, indeed, there are some fields of pure research in which it is the only compact yet comprehensive guide at present available. As points of departure, the works of Gildemeister and Hoffmann, Parry, and Simonsen are acknowledged. The older works may be set in perspective by the fact that of seventeen well-characterized natural sesquiterpenes described in Parry, only four are there assigned constitutions. All these, as Dr. Guenther records, have since been modified, and seven others in the group have been assigned with at least strong probability. Of thirty-three entries in the bibliography on diterpenes in the new volume, all but two are of later date than Parry's work. There is also evidence that references even to earlier work have been carefully checked.

Sir John Simonsen's work on "The Terpenes" (or rather Simonsen and Owen's in the new edition, when this is completed by a third volume) will, of course, partake still more of the authoritativeness of youth; but at present the American volume fills a unique position as an up-to-date text-book of the sesquiterpenes and diterpenes. A large part of its matter, moreover, namely, some 250 pages on non-terpenoids such as phenols, esters and lactones, is permanently outside Simonsen's scope; and even in their survey of common ground in the monoterpenoids, the difference in emphasis, as between Simonsen's primary interest in the unravelling of problems of constitution and Guenther's leaning to the practical interests of commerce and analysis, will amply justify space on the same shelf for both books.

It is perhaps unavoidable that the commercial and practical bias should enforce some rather arbitrary-seeming boundaries upon the subject-matter of the present work. The essential oils are, after all, a class defined by no natural character except volatility, a standard which is empirical at best, and liable to alter with changes in distillation technique; and a classification which, for example, excludes santonin while including so near a congener as alantolactone cannot seem wholly satisfactory from a chemical point of view. The further implication that an essential oil must be one which is pre-existent in the plant, and not generated in the isolation process, is a criterion not always easily applied to single constituents. Thus certain compounds such as guaiacol, though sometimes reported in essential oils, are excluded by Dr. Guenther, presumably on the ground of being secondary pyroligneous formations; sylvestrene, however, is allowed a monograph, though the evidence that it is not a natural plant product is admitted. In so far as it can give rise to such an element of waywardness in the scope of the book, the conception of 'essential oils' may have begun to outlive its usefulness. Yet it is easy to believe that no title less time-honoured, and less apt to kindle in the authors a sense almost of vocation in exploring the history and ramifications of an ancient industry, could have resulted in so much of solid excellence in the work they have, in fact, included.

Co-ordination of the various volumes of the work as a whole will clearly be a difficult task. The discussion of the structural relationships of the *p*-menthadienes, for example, is less clearly in place in this volume than in Volume 1, where a similar discussion, with the same table of structural formulæ, has already been given by Dr. Haagen-Smit. The observation in the monograph on artemisia ketone, that this compound is an exception to the isoprene rule, may seem at best inconsequent and at worst misleading, since in Volume 2 there is neither elucidation of this rule nor reference to Volume 1, and the existence of other exceptions (lavandulol, eremophilone and leptospermone) is obscured by the silence of the appropriate monographs. Such criticism assumes that where one volume is in use, the presence of the other may be expected; and it is no more than a fair appreciation of their merits to add that this assumption is certainly a just one.

E. G. KELLETT

FAMOUS DISCOVERIES IN PHYSICS AND CHEMISTRY

Historic Researches

Chapters in the History of Physical and Chemical Discovery. By Dr. T. W. Chalmers. Pp. vi+288. (London: Morgan Brothers (Publishers), Ltd., 1949.) 21*s.* net.

THIS volume consists of reprints of the author's articles on various classic researches in physics and chemistry which appeared in *The Engineer* during 1944–48. The field covered includes the problem of friction (Coulomb, Morin, Tower and Osborne Reynolds), the mechanical equivalent of heat (Rumford, Mayer, Joule and others), electrodynamics (Oersted, Ampère, Faraday), ether-drift (Arago, Michelson, Morley, Miller and Fitzgerald), specific, latent and atomic heat (from Black to Planck), the chemical elements and atoms (from antiquity to Dalton and Avogadro), the classification of the elements (Newlands, Lothar Meyer, Mendeléeff), molecular physics (Newton, Daniel Bernoulli, Joule, Clausius and Clerk Maxwell), the conduction of electricity through liquids (Davy, Faraday, Grotthuss and Kohlrausch), the conduction of electricity through gases (Faraday, Plücker, Hittorf, Crookes, Goldstein, Lenard, Perrin, J. J. Thomson, C. T. R. Wilson and Millikan), X-rays and positive rays and isotopes.

These great researches are narrated and discussed in a very interesting way; the illustrations are well chosen, and the author keeps his reader's attention throughout. Biographical and mathematical notes are given at the end of the book. References and documentation would have added greatly to the value and usefulness of the work.

It is to be regretted that the author repeats (p. 28) the usual account of what have become known as Davy's ice experiments; Davy did not carry out these experiments as they are customarily described, and such experiments as he made (when a youth of nineteen) had and could have had no influence on his contemporaries, as Prof. E. N. da C. Andrade showed in *Nature* some years ago (**135**, 359; 1935: see also *ibid.*, 878). The suggestion (pp. 105–106) that Priestley may have heard of Scheele's preparation of "fire air" before his own isolation of "dephlogisticated air" and made use of this knowledge is based on a misunderstanding, not only of Priestley's character, but also of the causes that led him to design the series of experiments which provided that most remarkable result. Further, Priestley's term, "dephlogisticated air", was not derived from the non-inflammability of this air (p. 104), but from its superiority over common air as a supporter of combustion and respiration, a conclusion that is not "fantastic" (p. 109). The paragraph on p. 101 dealing

with calcination as explained by the phlogiston theory unfortunately contradicts itself; the calx was regarded, not as a compound of the metal and of phlogiston set free from the fuel, but as the residuum of the metal after its component phlogiston had been expelled. D. McKie

BASIS OF PRESENT-DAY RUSSIAN AGRICULTURE

Principles of Agriculture

By W. R. Williams. Translated from the Russian by G. V. Jacks. Pp. 156. (London: Hutchinson's Scientific and Technical Publications, 1948.) 15*s*. net.

PROF. W. R. WILLIAMS, in spite of his name, was the leading communist professor of agriculture in the U.S.S.R. at the time of his death in 1939. Since that time his teachings have become more and more orthodox, until in present-day communist-dominated agricultural literature they rank with those of Michurin, Lysenko and a few others as the only sound basis on which to found agricultural research or state agricultural policies. Hence any book by Williams, such as the one under review, is indispensable for those who want to understand the trend of agricultural development behind the 'iron curtain'.

Williams spent the last years of his life as professor at the well-known Timiriazev Academy in Moscow. He was a superb lecturer and was adored by all his students, and this book will provide countless opportunities for appreciating how enlivening and how easy to understand his lectures must have been. For the outstanding characteristic in the exposition of his ideas is that there is practically no room for any trace of doubt or uncertainty; everything discussed is either excellent and usually communistic, or execrable and usually capitalistic or bourgeois, even if it is more typical of Russian than Western European agriculture. Hence there is no place in this book for any experimental proofs of the validity of his assertions; it is quite sufficient that he has made them. There can therefore be no question of considering this book as a scientific text-book—it would in medieval times have been ranked with the prophetic.

The book itself is a most extraordinary mixture of much extremely sound practical common sense, some appalling theoretical nonsense and some very out-of-date scientific theories. Naturally, Williams could not have acquired the reputation he has in the U.S.S.R. if his suggestions did not work well in practice; but this is no guarantee that the reasoning behind the methods is sound, as is only too well known to all scientific workers having to deal with successful farmers, even in Great Britain.

Williams's general thesis is that a sound agricultural system can only be built up where equal weight is given to crop husbandry, animal husbandry and soil cultivation—a contention that many people in Great Britain would consider self-evident; for the primary object of the farmer must be to maintain the tilth or structure of the soil, to ensure proper decomposition of the added organic residues, which helps to maintain the desirable structure, and to ensure adequate moisture and aeration, both for the plant roots and the soil micro-organisms. This can only be achieved by the regular use of long-term leys in the rotation, and this demands an adequate number of livestock to consume the grass and other by-products produced on the farm which are unsuitable for human food.

Williams is therefore a great exponent of the value of ley farming, and there is little in Stapledon's teaching of taking the plough round the farm that he would not thoroughly approve of. But his exposition of ley farming is always from the point of view of the soil tilth, so he is particularly interested in the root systems of the various grasses, the kind of plough and coulter to use when ploughing under the ley, and the methods of soil cultivation that cause the desirable structure produced by the ley to break down as slowly as possible. All through this discussion, his practical suggestions are excellent, and several could profitably be tried more extensively in Great Britain; but many of the reasons he gives for these are demonstrably false.

The translation of the book appears excellent, and it reads smoothly and clearly. The book itself will amply repay careful study by all interested in ley farming and in Soviet agriculture. E. W. Russell

NORTH AMERICAN ARACHNIDS

The Spider Book

A Manual for the Study of the Spiders and their Near Relatives, the Scorpions, Pseudoscorpions, Whip-Scorpions, Harvestmen and other Members of the Class Arachnida, found in America north of Mexico; with Analytical Keys for their Classification and Popular Accounts of their Habits. By John Henry Comstock. Revised and edited by Dr. W. J. Gertsch. Pp. xi+729. (Ithaca, N.Y.: Comstock Publishing Co., Inc.; London: Constable and Co., Ltd., 1948.) 35*s*. net.

THIS is a re-issue of the second (1940) edition of Prof. Comstock's well-known "Spider Book" of 1912. When the book first appeared, thirty-seven years ago, it received a well-deserved welcome, for at that time there was no other authoritative work describing the structure and habits of such orders of arachnids as occur in North America. For British readers its taxonomic sections had no great appeal; but the rest provided them with an admirable introduction to the biology of the Arachnida.

To a large extent this is still true, for the book contains all the 770 illustrations, in line and half-tone, which were so conspicuous a feature of its predecessor, while its survey of the scorpions, whip-scorpions and lesser orders has, I think, no serious competitor among books in the English language.

Yet Dr. Gertsch's policy—"the keynote of the revision has been conservatism"—provokes a feeling of disappointment. The study of spiders and their allies has not been unaffected by the passage of time, and, as no one knows better than Dr. Gertsch himself, there have been considerable advances in knowledge which he has elected to omit. True, he has incorporated the work of Roewer on harvestmen and of Chamberlin on false-scorpions in the appropriate pages; but, even so, one cannot but believe that an opportunity has been allowed to pass.

There may, of course, be reasons for this, not yet apparent; in the meantime, the book can be recommended as an attractive survey of the Arachnida of North America, wholly reliable within the limits just mentioned. T. H. Savory

A Textbook of Heat

For Upperclassmen. By Prof. LeRoy D. Weld. Pp. x+436. (New York: The Macmillan Company; London: Macmillan and Co., Ltd., 1948.) 25*s*. net.

THE student approaching the subject of heat must master principles which require a previous background of experiment, and at the same time learn to appreciate a variety of experimental methods demanding a prior understanding of theory. The teacher's business is to make this cycle work irreversibly, and Prof. LeRoy D. Weld's text-book, based on courses of university lectures given during the past thirty-five years, is skilfully arranged to this end. The text, describing a limited number of important experiments, is chiefly an explanation of principles. References for supplementary reading, mostly on modern experimental techniques, are given at the end of each chapter. These, leading the reader to range among selected American periodicals, might perhaps have been classified into groups, for it would have been useful to have the review articles and theoretical discussions distinguished from the purely experimental papers.

The treatments of the kinetic theory of gases and of thermodynamics are particularly instructive, and illustrated with many good numerical examples. Conduction, thermo-electricity, and thermionic emission are grouped together as a study of metals, which does not go into great detail, but concludes with a brief introduction to Fermi–Dirac statistics. A few unfamiliar terms appear. The standard unit volume, useful for critical constant calculations, is named the "suv". Surface emissivity is called "Newtonian radiation coefficient", which is less ambiguous but more misleading. And would the quantum-theory calculations on atomic heats be called "quantum-mechanical methods" to-day?

The author has planned the book with care, and students should find it pleasant and stimulating to work through. It can be recommended as a useful presentation of the theory of the subject, of between intermediate and general-degree standard.

G. R. N.

Isotopenbericht

Tabellarische Übersicht der Eigenschaften der Atomkerne, soweit bis Ende 1948 bekannt. Von Josef Mattauch und Arnold Flammersfeld. (Sonderheft der *Zeitschrift für Naturforschung*.) Pp. 243. (Tübingen: Verlag der *Zeitschrift für Naturforschung*, 1949.) n.p.

THE use of isotopes, stable and radioactive ones, is increasing fast in science, medicine and industry. J. Mattauch and A. Flammersfeld have done an important service to all workers in this field by going critically through a vast amount of literature in order to produce these isotope tables.

While similar tables published by Seeborg and Perlman have been of great use, the authors have gone further by incorporating in their book not only the half-life, radiation details, production methods, abundance and spin of isotopes, but have also added mass-spectrographic measurements, reaction energies of nuclear reactions and activation cross-sections by thermal neutrons. In addition, they have reproduced eighty-three disintegration schemes of isotopes. Most of the literature until the end of 1948 has been incorporated. In some cases, like, for example, iodine-131 and tantalum-182, the radiations taken from the disintegration schemes do not coincide with the tables in the first part of the book. This seems to be due to last-minute alterations and additions; but in spite of these inconsistencies, the incorporation of these schemes is extremely valuable.

There is no doubt that there will be a big demand for these tables as they are of very great assistance to research workers, and it is only hoped that the tables will be kept up to date as promised in the introduction. It is regretted that the binding of the book may not stand up to the frequent handling to which such an important reference book will be subjected.

HENRY SELIGMAN

The Philosopher's Way

By Jean Wahl. Pp. xiv+334. (New York and London: Oxford University Press, 1948.) 21*s*. net.

THE purpose of this book, we are told, is not so much to look for solutions as to recognize problems. Such a method, in philosophy, raises the question for whom exactly the author is writing; the answer is, for those who wish to follow the continuity of thought in the light of historical development. The chapters on reality, being, existence and so on are, in effect, descriptions of the positions assumed by the various schools, presented with a clarity to be expected from a French source.

A good feature is the weight accorded to several authorities not commonly read in Great Britain. Borderline cases like the works of Kierkegaard and Husserl (available, but all too seldom consulted) are discussed sufficiently to indicate the profound influence they have had on the progress of knowledge.

A particularly able account is given of the nature of transcendence; in the reviewer's opinion there has seldom, if ever, been a better. The character of this concept may be briefly described as asymptotic; it is always approaching something just beyond our reach, and it is this property which gives it its value.

F. I. G. RAWLINS

The Annual Register

A Review of Public Events at Home and Abroad for the Year 1948. Edited by Ivison S. Macadam, assisted by Hugh Latimer. Pp. xvi + 515. (London, New York and Toronto: Longmans, Green and Co., Ltd., 1949.) 42*s*. net.

THE present issue of this familiar book of reference marks the hundred and eighty-ninth year of continuous publication. As a survey of the history of the world it has no equal. The editor is assisted by an advisory board of six, nominated by various bodies, including the British Association for the Advancement of Science. Most members of this board, and also a large number of other writers, contribute to the volume, which is thus assured of authoritative articles. The arrangement and scope from year to year differ little. At home and abroad a dominating aspect of the history of 1948 was the challenge of Communism. Part 1 is a full, vivacious and unbiased history of the United Kingdom. It includes a striking chapter on the state of the nation in that trying year. Part 2 deals with the British Commonwealth, and Part 3 with foreign history. Part 4 contains a chronicle of events, some obituaries and reviews of literature, science, the arts, etc. The chapter on science is full and comprehensive and a great improvement on the scope of the review in past years. Several treaties and other public documents are given in full.

THE SAVILIAN PROFESSORSHIPS

By Eng.-Capt. EDGAR C. SMITH, O.B.E., R.N.

WHEN Sir Henry Savile, the Elizabethan scholar, in 1619 founded the Savilian professorships of geometry and astronomy at Oxford, he was seventy years of age, and for fifty-eight years had been connected with the University. He began his studies there in 1561 when a boy of twelve, at sixteen he took the degree of B.A. and at twenty-one was made a fellow of Merton College, of which in 1585, after much study and travel, he became Warden. Though also from 1596 Provost of Eton, it was the University of Oxford which had the first place in his affections and none knew better than he the needs of the time. Born in the reign of Edward VI, he lived through the reigns of Mary and Elizabeth and most of that of James I. He was a boy of six when Latimer and Ridley met their deaths at the stake, and reader in Greek to Queen Elizabeth when Bruno lectured at Oxford. He heard much about religious persecutions and wars, but lived peacefully enough, devoted to his College and his books (see also p. 906).

Savile was active at a time when the views of Copernicus were gradually gaining ground, and his life overlapped not only those of the great Elizabethan seamen and writers, but also those of Galileo, Kepler, Gilbert, Bacon and Descartes. Three years before Savile's birth in 1549, the five regius professorships of divinity, Hebrew, Greek, civil law and medicine had been founded at the Universities; but it was only those of medicine which in any way touched science. Edinburgh had founded chairs of mathematics and natural philosophy in 1583, and in 1596, through the generous provision of Sir Thomas Gresham, the seven Gresham professors, including those of geometry and astronomy, had begun their lectures in Gresham's mansion in Old Broad Street, London. But neither Oxford nor Cambridge could boast of such chairs, and Savile no doubt was much influenced by what was being done by Briggs and his colleagues in London. In 1619 he therefore decided to devote a portion of his fortune towards the founding of the Savilian professorships, which have now been in existence three hundred and thirty years and have been held by some of the most eminent of British men of science. In the preamble to the deed of foundation, it was said that geometry was almost totally unknown and abandoned in England, and it was to remove this evil that Savile established the chairs of geometry and astronomy open to mathematicians from any part of Christendom.

There have been thirty holders of the Savilian chairs, a list of whom is given in the accompanying table. With the exceptions of Caswell, Betts and Dr. J. Smith, sketches of their careers are to be found in the "Dictionary of National Biography" and elsewhere. Appointments to the chairs were not always made on the scientific attainments of the candidates, for influence, political opinions and religious views all had their effect. In William Whiston's memoirs will be found the story of how Halley at one time was considered unsuitable for a Savilian chair, and it may perhaps be recalled that it was not until the repeal of the Test Acts that Cambridge conferred a degree on Sylvester, though he had qualified for it forty years before.

List of Savilian Professors

Geometry		*Astronomy*	
1619	Henry Briggs	1619	John Bainbridge
1631	Peter Turner	1643	John Greaves
1649	John Wallis	1649	Seth Ward
1703	Edmund Halley	1661	Christopher Wren
1742	Nathaniel Bliss	1675	Edward Bernard
1765	Joseph Betts	1691	David Gregory
1766	John Smith	1709	John Caswell
1797	Abraham Robertson	1712	John Keill
1810	Peter Rigaud	1721	James Bradley
1827	Baden Powell	1763	Thomas Hornsby
1860	H. J. S. Smith	1810	Abraham Robertson
1883	J. J. Sylvester	1827	Peter Rigaud
1897	William Esson	1839	G. H. S. Johnson
1919	G. H. Hardy	1842	W. F. Donkin
1931	E. C. Titchmarsh	1870	Charles Pritchard
		1893	H. H. Turner
		1931	H. H. Plaskett

That there was at first a close connexion between Merton College, Gresham College and the Savilian professorships can be seen from the fact that Briggs, Turner, Greaves and Wren all held chairs in London before being appointed at Oxford. This connexion between Oxford and London was further strengthened by the meetings in both cities of some of the earliest Fellows of the Royal Society, such as Wilkins, Ward, Willis, Petty, Boyle and others. Another link was forged by the inauguration of the Royal Observatory at Greenwich, where Flamsteed was succeeded by Halley and he in turn by Bradley and by Bliss. Some of Bradley's most important work was done while he still held only his Oxford appointment.

On the founding of the Savilian chairs, Savile himself read a few lectures on Euclid; but Briggs began his course in January 1620 with an oration, and Dr. John Bainbridge at the same time became his colleague. Both of them had taken degrees at Cambridge, where Briggs while an examiner in mathematics had read the Linacre Lecture in medicine. The turning point in his career was his visit to Napier of Merchiston in 1615, from which time onwards he was ever immersed in the task of compiling the logarithmic tables for which he is remembered. In a sense, Briggs was a professional mathematician, unlike many of his contemporaries holding neither holy orders nor practising as a physician. Bainbridge, on the other hand, was a general practitioner, and from 1618 a licentiate of the College of Physicians. In that year he observed and described a comet, and this led to his acquaintance with Savile and his appointment to the chair of astronomy. The next occupants of the chairs were Peter Turner and John Greaves, both Gresham professors, of whom Greaves is remembered for his travels in the Near East and his arduous measurements of the Pyramids, a reference to which was made by Sir Richard Glazebrook in his Guthrie Lecture to the Physical Society in 1931. In the time of Turner and Greaves, Oxford was the headquarters of Charles I, and it was perhaps natural they should have Royalist leanings. This, however, was their undoing, for on the ascendancy of the Parliamentarians they were

ejected from their professorships and both died in London in 1652. Briggs and Bainbridge, it may be mentioned, were buried in Merton College chapel; but Greaves was buried in St. Benet Sherehog, in the City of London, and Turner in St. Saviour's, Southwark.

To the vacancies created by the dismissal of Turner and Greaves were appointed John Wallis and Seth Ward, both of whom could be trusted to steer a safe course with Parliamentarians and Royalists. They had taken holy orders and they both became original Fellows of the Royal Society; but whereas Ward abandoned the lecture room for the pulpit and became first bishop of Exeter and then bishop of Salisbury, Wallis continued to hold his chair of geometry for fifty-four years, making important additions to mathematics. All these worthies lived in the difficult times which saw the Civil War, the Commonwealth and Restoration; but Wallis, like Savile before him, continued steadily on his course, once writing that "it hath been my Endeavour to act all along, by moderate Principles, between the Extremists on either Hand, in a moderate Compliance with the Powers in Being . . . and to make the best of what is, and hereby, through God's gracious Providence, have been able to live easy and useful, if not great".

On his great contemporary Sir Christopher Wren, or on Halley and Bradley, there is little need to dwell. Wren's deputy and successor, Dr. Edward Bernard, was an indefatigable collector and translator of ancient mathematical works, and we are told "an Englishman whom few of this age equalled in erudition and in modesty scarcely any". Retiring in 1691, he spent the last six years of his life in a Berkshire rectory.

With the appointment of David Gregory to the chair of astronomy, a new era in scientific instruction in Oxford opened, for with him came his Edinburgh pupil John Keill, and it was they who first explained and demonstrated by experiments, to Oxford audiences, the work of Newton. Unfortunately, Gregory died when only forty-seven, and Keill when but fifty. Their contemporary, John Caswell, had been a servitor at Wadham College for eight years and became vice-principal of Hart Hall. He was fifty-seven when he died on April 28, 1712. Halley, it was said, would have liked the chair vacated by Bernard; but Bishop Stillingfleet and others had misgivings through Halley being a sceptic, and the future Astronomer Royal had to wait until the death of Wallis, when he was given the chair of geometry. In the interval, he had added to his already great reputation by his voyages, which resulted in the publication of his "General Chart of the Variation of the Compass".

Of the other eighteenth-century Savilian professors, special reference may be made to Thomas Hornsby, who was also Radcliffe Observer, Radcliffe Librarian and Sedleian professor of natural philosophy. He spent the whole of his life in Oxford. To him fell the task of superintending the building and equipping of the Radcliffe Observatory and commencing the long series of observations made therein. He was thirty when he succeeded Bradley and he held the chair for forty-seven years. The Radcliffe Observatory was built during 1772–78 by the trustees of the famous Dr. John Radcliffe. Some of its history was given by Mr. Justice Bennett in his judgment delivered in the High Court of Justice in July 1934, when the Radcliffe trustees applied for permission to devote a sum, derived from the sale of the Observatory and grounds to Lord Nuffield, towards the founding of a new Radcliffe Observatory on 57 acres of land at Klapper Kop, South Africa, given for the purpose by the Municipality of Pretoria. As both Savilian professor of astronomy and Radcliffe Observer, Hornsby was succeeded in turn by Robertson, Rigaud, Johnson and Donkin, after whom the functions of professor and observer were separated.

Another interesting figure among the Savilian professors of more than a century ago was Stephen Peter Rigaud, whose career recalls the scientific work of other French Huguenot families who came to England as refugees. Such were the Dollonds, the Desaguliers and the Demainbrays. The Demainbrays, father and son, were the King's astronomers at Kew, where an observatory was built shortly before that at Oxford. The Rigauds, Stephen Peter and his father, assisted the Demainbrays, and no doubt Royal favours had something to do with Rigaud's appointment to the Savilian chair of geometry, afterwards exchanged for that of astronomy. A Fellow of Exeter College, he became a deputy for Hornsby, and on becoming Radcliffe Observer added to the instruments in the Observatory. He was a copious correspondent, and he published works on Newton, Bradley, John Hadley and James Stirling, and also "An Account of some early Proposals for Steam Navigation".

The part played by Hornsby in the eighteenth century had its counterpart in the nineteenth century when the Rev. Charles Pritchard became Savilian professor of astronomy, for it was under him the "New Savilian Observatory for Astronomical Physics", now the University Observatory, was erected, having among its instruments those given by Warren De la Rue. Though sixty-two when appointed, Pritchard entered upon his duties with the ardour of youth and maintained his enthusiasm until his death at eighty-five. His immediate successor was the late H. H. Turner, while the present holder of the chair is Prof. H. H. Plaskett, son of the eminent Canadian astronomer, the late Dr. J. S. Plaskett. Prof. Plaskett's previous appointment had been that of professor of astrophysics in Harvard University. He is thus the first from overseas to hold a Savilian chair.

Such scientific instruction as was given at Oxford in the eighteenth century was mainly confined to the various branches of physics, the lecturing on which was often entrusted to deputies. As for mathematics, it is common knowledge that both Oxford and Cambridge lagged far behind the Continental schools, and even when, through the labours of Woodhouse, Peacock, Babbage and Herschel, mathematics at Cambridge entered upon its golden age, there was no similar movement at Oxford. It thus came about that the early Savilian professors of geometry, Briggs and Wallis, had no comparable successor until Henry John Stephen Smith succeeded Baden Powell in that chair. Powell's main interests had centred around optics and university reform. Of Irish parentage, and unusually gifted, Smith became, in spite of much ill health, a mathematical lecturer at Balliol College, and in 1860 succeeded to the Savilian chair, which he held until his death in 1883 at the age of fifty-six. His reputation as a mathematician was world-wide, while, wrote Dr. J. W. L. Glaisher, "It is difficult to give an idea of the position Professor Smith held in Oxford and in society generally, so brilliant were his attainments and so great and varied his personal

and social gifts". No Savilian professor has had the distinction of representing the University in Parliament; but according to G. W. E. Russell, in 1879, "The Liberals by a strange perversity of choice brought forward Professor Henry Smith, a mathematical genius of the highest rank but so half-hearted a politician that E. A. Freeman said that he was better qualified to sit as member for Laodicea in the Parliament of Asia Minor".

Smith had been appointed to the chair of geometry at the age of thirty-four; his successor, James Joseph Sylvester, was twice that age, having been born in 1814. A Wrangler in 1837, his Jewish parentage had debarred him from a degree, and before being appointed to Oxford he had held professorial posts in London, Woolwich, Virginia and Baltimore. He continued to lecture at Oxford until about 1892, when through his failing eyesight, William Esson was appointed his deputy and eventually his successor. A Fellow of Merton College since 1860, Esson at one time collaborated with the distinguished chemist, A. G. Vernon Harcourt, and held University offices. To one student Esson's mission seemed to be "to illuminate mathematically the obscure records of chemical velocities". After teaching for a very long period, he died in 1916, and in 1919 was succeeded by Prof. G. H. Hardy, who died at Cambridge so recently as December 1, 1947. *The Times*, in its obituary of him, said that he was "perhaps the greatest pure mathematician of his day—he would certainly be ranked in the first half-dozen—and one of the most familiar 'characters', both of Oxford and of Cambridge. . . ." A tribute to Hardy was paid by Prof. M. H. A. Newman in a broadcast, printed in *The Listener* of January 22, 1948. In 1931, Hardy had returned to Cambridge and Prof. E. C. Titchmarsh succeeded to the Oxford chair, having previously held the chair of pure mathematics at Liverpool.

These brief and all too meagre notes will perhaps give some idea of the benefits which have accrued to science in Oxford through the far-sighted action of Savile. It is possible that Oxford can claim a longer list of such benefactors than any other university in the world; Her colleges, halls, chapels, libraries and museums, her professorships, lectureships and scholarships recall the names of kings and nobles, chancellors and prelates, teachers and scholars and men of many degrees. To the visitor to the city it might be said: "If you wish to see their monuments look around". Their influence has spread throughout the world; but among them all, few deserve to be remembered more than Sir Henry Savile, whose memorial, like that of his close friend Thomas Bodley, is to be seen in the chapel of Merton College, which he served so faithfully and so long.

AFRICAN REGIONAL SCIENTIFIC CONFERENCE

THE first African Regional Scientific Conference was held in the University of the Witwatersrand, Johannesburg, during October 17–28, and was convened by the South African Council for Scientific and Industrial Research as a result of a recommendation made at the Commonwealth Scientific Conference held in London in 1946. The object of the African Conference was to consider ways and means of securing a greater measure of co-operation between the different territories in Africa south of the Sahara in problems involving research of a long-term nature. There were 107 delegates, representing the various African territories concerned and the Metropolitan Governments with direct interests in this part of Africa, present at the Conference. There were also observers from the World Health Organisation, Food and Agriculture Organisation, United States National Research Council, United Nations Educational, Scientific and Cultural Organisation, and the Overseas Food Corporation.

The Belgian delegation was led by Dr. P. Staner, of the Colonial Ministry, Brussels, the French delegation by Prof. J. Millot, director of the Institute for Scientific Research in Madagascar, the Portuguese delegation by Dr. A. A. E. M. Correia, director of the Colonial Training College of Portugal, the United Kingdom delegation by Sir Ben Lockspeiser, secretary of the Department of Scientific and Industrial Research, and the South African delegation by Dr. B. F. J. Schonland, president of the South African Council for Scientific and Industrial Research.

During the period of the Conference, the delegates were the guests of the Union Government. They were entertained at a number of functions and were given the opportunity of visiting some of the scientific institutes in the Johannesburg and Pretoria areas. The University of the Witwatersrand conferred honorary degrees upon the leaders of the various national delegations. At the conclusion of the main business of the Conference, delegates were taken on a short tour of the wild-life sanctuary in the Eastern Transvaal, the Kruger National Park, where they saw a wide variety of animals.

The Conference was officially opened by the Prime Minister of the Union of South Africa, Dr. D. F. Malan, and his opening address was followed by messages of welcome from the heads of the various delegations. On the proposal of Sir Ben Lockspeiser, Dr. P. J. du Toit, formerly director of the Onderstepoort Veterinary Research Institute and now deputy president of the South African Council for Scientific and Industrial Research, was unanimously elected as president of the Conference. This post he filled with great tact and skill, which contributed greatly to the successful outcome of the Conference.

The first two days were devoted to plenary sessions at which delegates from the various territories delivered statements on the general organisation and research in the various countries and regions. Thereafter the Conference was split into six Sections, as follows: (A) physical environment; (B) soils and plants; (C) zoology and animal industry; (D) health and medical research; (E) social research; (F) technology. Chairmen elected for each Section were: (A) Dr. S. H. Haughton, geological adviser to the Union Government; (B) Prof. A. Quintanilha, director of cotton research in Portuguese East Africa; (C) Prof. L. van den Berghe, director of the Institute for Scientific Research in Central Africa (Belgian Congo); (D) Sir Edward Mellanby, secretary of the Medical Research Council in Great Britain and chairman of the Colonial Medical Research Commission; (E) Prof. T. Monod, director of the French Institute for Black Africa at Dakar; and (F) Dr. E. B. Worthington, of East Africa.

Within the sectional meetings, spread over six very full days, 118 papers by delegates and other expert contributors were presented. The papers had been printed in advance, and were only very briefly summarized by the authors at each meeting, the principal

object of the meetings being the discussion which followed. The general scope of the papers and discussions covered surveys and maps; geology and geophysics; meteorology and hydrology; soils and soil conservation; botany and plant industry; forestry; zoology; animal industry; the biology of water; health; medical research; social research; building research; road research; industrial research; and library and information services.

It was apparent from the outset that the delegates from the various countries were meeting on common ground of great mutual interest and that they shared the firm conviction that co-ordination of scientific effort in Africa south of the Sahara was a vital need. It was also obvious that each territory felt very acutely the shortage of trained scientific workers, and this matter cropped up repeatedly in discussions on a wide variety of topics. In view particularly of the small number of highly trained men of science in Africa, the wastage of scientific man-power in the performance of routine duties was generally deplored. Although no specific resolution on this matter was brought before the plenary session, it was felt that the expenditure of a relatively small amount of additional money on the provision of laboratory assistants would alone result in a greatly increased output of scientific work.

Another matter which intruded itself into discussions on many occasions was the need for compiling and comparing, in the form of maps, a large number of facts of importance for progress in scientific research and in the economic development of Africa. This culminated in a resolution to the effect that the Conference recommends that each main region in Africa should arrange for the production of small-scale maps or atlases—where necessary on a basis of inter-State collaboration—in order to provide information on the physical environment (geological, climatological, hydrological, etc.), the biological environment (vegetation, fauna, insects as vectors of disease, etc.), and human facts (race pathology, demography, ethnic groups, languages, communications, economic factors, etc.). This work should, if possible, be co-ordinated and produced on a uniform system so that the maps which result could provide a scientific outline of Africa.

The desirability of achieving uniformity in ordinary maps of Africa south of the Sahara was the subject of another resolution adopted at the plenary session. It was considered that, so far as possible, map projections, sheet boundaries, scales and conventional symbols for use on maps should be uniform in order that maps of adjacent territories might be directly comparable. It was also suggested that the figure of the earth used in geodetic calculations should be uniformly agreed. The attention of governments was directed in another resolution to the considerable benefits to be derived by many branches of scientific research in Africa from complete air photography of their respective territories, quite apart from the use to which air photographs could be put in the production of topographic maps.

Resolutions from Section A which were unanimously adopted at the final plenary session include, in addition to the ones already mentioned above, a resolution calling for the establishment of a regional bureau for geological and mineral research to serve the territories in Africa south of the Sahara as an organisation for collecting and disseminating information on the aspects of those subjects which are of common interest, and to act as a co-ordinating agency in the field of geological research. It was recommended also that palæontological research in Africa should be one of the subjects to be dealt with by the proposed bureau.

In the field of geophysics the Conference considered that provision of more instruments is necessary for the further study of such features as the seismicity of the African continent and gravitational variations within its boundaries. The extension of ionospheric and magnetic observations is desirable, as well as collaboration in the study of radio noise levels and the physical constants of the ground at radio frequencies. In meteorology it was considered that further co-ordination might be effected through an organisation linked with the African Regional Commission of the International Meteorological Organisation.

Presented originally as a recommendation from Section A, but overlapping with suggestions from several other Sections, a composite resolution on hydrology was adopted by the Conference. It was urged that steps be taken to organise the systematic collection and publication of all stream-discharge and related records, and to expand long-term hydrological research in the widest sense so as to include investigations on the influence of agricultural, piscicultural and forestry forms of land use on infiltration, evaporation, transpiration, run-off, stream-discharge and ground water, as well as their effects on health.

Resolutions adopted on the recommendation of Section B covered several aspects of pure and applied agricultural and botanical research. The setting up of an inter-African bureau of information on the conservation and utilization of the soil, arising out of the 1948 Goma Conference, and the establishment of an inter-African pedological survey at Yangambi in the Belgian Congo, were warmly approved. It was urged that, as increasing demands for food must lead to the increasing expansion of agriculture into the semi-arid regions of Africa, steps be taken to secure an early assessment of relevant knowledge available in the several branches of the sciences concerned with research on agriculture in such regions. The recognition of the importance of soil microbiology in soil fertility problems led to the recommendation that adequate facilities for fundamental soil microbiological studies and for the training of microbiologists in African territories be established. Adequate facilities were also required for fundamental studies on plant physiology and investigations on fungi and plant nematodes. Intensified research into the wastage of fruit through decay between production and consumption was also urged, and it was recommended that research be conducted with the view of making possible the expansion of deciduous fruit production in the inter-tropical zone. The Conference also stressed the urgent necessity for intensifying botanical research in taxonomy, ecology and plant geography in order that fundamental information essential to research workers in applied science, now often inadequate or lacking, should become available for the economic development of the continent.

In Section C a similar need for basic taxonomic and ecological research as a foundation for other work was the subject of an independent resolution, also adopted by the Conference. It was considered desirable that steps be taken to compile a list of types and paratypes of zoological specimens in Africa, together with information concerning the places where they are housed. The ringing and marking of mammals, birds and fishes should be undertaken

on a large scale in order that studies of migration might be made. A well-planned survey of ticks and other disease vectors in Africa south of the Sahara should also be undertaken, as this affects both human and animal life.

More intensive and extensive investigations on the vast problem of poisoning by plants was also considered necessary. The Conference recommended, too, that an animal nutrition survey be initiated in view of present inadequacy of knowledge regarding nutritional matters and other factors which result in devastating stock losses in the continent. Because of certain present limitations in the development of animal production in Africa, it was considered necessary that the fishing resources be developed as an additional source of animal protein.

The subject of wild-life protection aroused widespread discussion during the meeting, and resulted in a unanimous resolution from all Sections that biologists should play a prominent part in the conservation of wild plant and animal life in all African States. It was urged that a central body for the co-ordination of wild-life research in Africa be established, and that a mammalian survey be initiated as soon as possible. The Conference also requested that at least one centre be created, preferably in each region, where research teams could carry out comprehensive and fundamental work on the safeguarding of the natural resources of soils, water and fertility at every level of plant production that modern developments may demand.

Of the recommendations from Section D, those adopted by the Conference concerned malnutrition, vector-borne diseases and environmental studies. It was recommended that every facility be given to expanding work on investigating malnutrition in human beings, more especially by ensuring closer co-ordination and consultation between research workers. This was considered vitally important, since malnutrition appears to be a widespread cause of subnormal health and development in Africa. It is also desirable that long-term research be undertaken to discover the potentialities of the African in general, and this can best be done by regional teams of scientific workers with a central committee to co-ordinate their research. Attention was directed to the need for a proper study of the African environment and its influence on human health, and the adaptation and acclimatization to such an environment of the different races living in Africa. The Conference recognized the need for providing facilities for special postgraduate training on research in African diseases and recommended that a specialist conference be called to consider problems of malaria research and control. Additional research is also necessary on bilharziasis and virus and rickettsial diseases.

Acting on recommendations from Section E, the Conference considered that investigations on the social sciences should be undertaken, mainly on territorial lines, in which the co-operation of all existing organisations should be ensured. A social-research liaison organisation is needed to keep the various organisations informed of activities, to co-ordinate research projects, and to facilitate the movements of research workers between the various regions; psychological studies and social surveys are also necessary. It was pointed out that attention should be paid to uniformity of sampling methods and uniformity of bases for the collection of statistical information. The Conference suggested that, in addition, a demographic committee be set up in order to co-ordinate and encourage demographic surveys. Also from Section E came a resolution which resulted in the Conference endorsing the resolution passed at the first Pan-African Congress on Prehistory held at Nairobi in 1947, when matters relating to the need for archæological surveys and the preservation and scientific excavation of prehistoric and other archæological sites were dealt with. The Conference stressed the need for intensified exploration with scientific support, and the preservation of prehistoric sites for systematic study and as 'museums on the spot'.

The recommendations from Section F were concerned with a variety of technological problems and for the most part emphasized special needs which could be investigated on territorial lines with the assistance of co-ordinating bodies, rather than with recommendations for the setting up of new organisations. Attention was directed to the importance of the problems of water pollution in tropical waters and the need both for further research and for the interchange of information. Fisheries research and fish technology could take advantage of existing or proposed organisations; but there is urgent need for collaboration in the collection of fishery statistics. More investigation is desirable on the technological problems of utilizing phosphate rocks for the production of fertilizers. Research in all the technical and economic aspects of road planning and road construction and maintenance is desirable, and special attention might advantageously be given to the problems of low-cost roads. It was suggested that a meeting of specialists should be convened to consider road research matters in the near future.

The establishment of processing and other industries in tropical Africa is becoming urgent, and the lack of much basic information and sound industrial research in Africa is hampering the effective expansion of industry. The Conference also emphasized the importance of good housing, and directed attention to the need for uniformity of methods in assessing climate, since this is a basic factor in the design of buildings. There is also a demand for research into the behaviour of building materials under African conditions and a need for the establishment of local industries for the production of building materials.

Another resolution which was enthusiastically adopted stressed the necessity for adequate library and information services to meet the requirements of men of science in Africa, and suggested the preparation of a directory of library and documentation centres in Africa and the compilation of a unified list of the holdings of scientific and technical journals in African libraries. It was also suggested that a number of regional photographic units should be set up for the purpose of making single copies of articles from scientific journals. A related resolution advocated that scientific papers in English or French might advantageously include summaries in the other language.

During the course of the discussions in the various Sections, the steering committee of the Conference, comprising the president, the leaders of the delegations and the chairmen of Sections, developed a scheme which was ultimately adopted with enthusiasm by the plenary session. The Conference recommended the establishment of a scientific council for Africa south of the Sahara as an advisory and consultative body composed of men of science representing both the subjects and the regions concerned.

The functions of the council, which should be exercised in full co-operation with the specialist bureaux and other inter-territorial organisations, would be to encourage research workers and establish contacts between them, and to study what research projects of common interest could be usefully suggested to governments, research agencies or universities. Other aims of the council would be: to endeavour to facilitate the exchange and movement of scientific workers between different territories and to promote liaison between inter-government scientific bureaux or other bodies; to arrange for the compilation and distribution of information of general value concerning the locations of scientific workers, scientific equipment and specialist libraries; to foster, in respect of each of the major scientific subjects, the creation, in Africa, of centres of specialist documentation; to convene, with the consent of the Governments concerned, periodic conferences of a general scientific character and facilitate meetings of groups of specialists; and to submit recommendations to the Metropolitan Governments concerned in order to secure joint administrative action through a proposed inter-government committee for technical collaboration.

It is not intended that the proposed scientific council for Africa would itself establish any institutions or laboratories, or would itself actively direct research programmes; its main function would be to obtain a broad view of what research is being undertaken in Africa in order to minimize unnecessary overlap of effort and co-ordinate the work. Such an organisation would draw its strength from periodic conferences and meetings between scientific workers, but at the same time would ensure that such conferences are arranged on a rational plan with due regard to the expense involved. It is not anticipated that a large staff would be required, and the moving force of the council should be provided by a chairman able to give his whole time to the new organisation and direct a small personal secretariat.

The Conference suggested that the first chairman should be nominated for two years by agreement between the Metropolitan Governments, and stated that it would be happy to see Dr. P. J. du Toit nominated to this post. It also recommended that the governments concerned should establish, as soon as possible, a commission which might consist largely of members of the steering committee of the Conference to give shape to the proposal now put forward and to ensure its realization. It is felt that, should this council come into being, it will mark a major step in the progress of scientific research in Africa south of the Sahara.

H. B. S. Cooke

INSECT FLIGHT AND DISTRIBUTION

THE pattern of the geographical distribution of insects is very varied; but among the widely distributed species we can recognize easily two types. First, the species which develops many local or geographical races, such as the swallow-tail butterfly (*Papilio machaon*) and the apollo butterfly (*Parnassius apollo*) in Europe; and secondly, the species which has little or no geographical variation over very large areas, such as certain locusts or the painted-lady butterfly (*Pyrameis cardui*). This latter type of distribution indicates a population within the area of which there are few natural barriers, and within which there is a continual mixing of individuals. It is associated with species which have great powers of movement; and this movement can be either active and deliberate, as in the migration of locusts, or passive, due to distribution by air currents, as in the Aphidæ and other small insects. By either of these methods, large numbers of individuals can move hundreds of miles.

At the recent British Association meeting at Newcastle upon Tyne, Section D (Zoology) held an afternoon session devoted to these problems of insect flight and distribution. Dr. C. B. Williams opened the discussion with an account of the deliberate migrations of insects. This type of movement is found chiefly in the larger insects, and particularly in locusts, moths and butterflies, and in dragonflies and beetles (especially the Coccinellidæ). As a result of these movements, many millions of individuals belonging to hundreds of species regularly move hundreds of miles, and occasionally more than a thousand miles. Inland seas like the Mediterranean are regularly crossed by millions of insects. In the British butterfly fauna of sixty-eight species, about one-quarter is known to cross the Channel or the North Sea each year or at more irregular intervals.

One of the greatest migrants known in the Lepidoptera is the monarch butterfly (*Danaus plexippus*) of North America, which flies from southern Canada to the Gulf States and to southern California every autumn, and then, after a period of semi-hibernation in the south, flies north again in the spring. This double flight of this species may well cover more than two thousand miles. Another great migrant, the painted-lady butterfly (*Pyrameis cardui*), flies from North Africa through Europe each spring, and sometimes reaches Iceland, a distance of nearly 1,500 miles. At the other side of the Atlantic, the same species, indistinguishable even as a race, flies in a similar way in the spring from western Mexico northward and eastward to cover in some years most of the United States and southern Canada.

Students of insect distribution must thus recognize that many species of insects may, by their own deliberate movements, be spread regularly over distances of more than a thousand miles, and may reach oceanic islands and other isolated localities; so that in such circumstances the setting up of a local race or a special gene-complex is almost impossible. Only in the Australian and New Zealand area is the local race of the painted-lady butterfly (*P. cardui kershawi*) distinguishable from those of the rest of its almost world-wide range. From an economic point of view, the control of insect pests which are capable of long-distance migration in great numbers brings quite different problems from those of the comparatively sedentary species.

In the next paper, Prof. A. C. Hardy gave an account of his early work in trapping insects in the upper air by means of nets hanging from kites and towers on land, and from the mast-heads of ships crossing the North Sea. The insects thus caught are nearly all small, such as Aphidæ, Chalcidæ, and other small Hymenoptera, beetles (especially Staphylinidæ) and occasionally small moths and lace-wings (Chrysopidæ). The number of insects over land is greatest near the ground and falls off at first rapidly as the level of trapping is raised; but small numbers were caught at heights above a thousand feet.

Most of the trapping over the North Sea was done by nets flown at mast-head when the ships were more

than a hundred miles from land. Under these conditions many hundreds of insects were captured, both by day and at night, indicating an enormous population of floating and drifting insects in the air at least a hundred miles away from any locality where they could have been carried up by air currents. More insects were found when the easterly winds were blowing from the Continent of Europe than with westerly winds from Britain. Attempts were made to obtain from air trajectories the possible origin and routes taken by the insects captured on particularly good and particularly bad days. These indicated that many insects had drifted for more than twenty-four hours and had come several hundred miles in their involuntary flight. Since the Second World War, Prof. Hardy has made experiments with nets trailing behind a helicopter flying over the English Channel at heights of 500–1,000 ft.; but the results were disappointing, and work from the masts of ships has been resumed instead. It appears possible that insects over the sea are at a lower level than those over the land.

Dr. C. G. Johnson described his recent studies of the insect drift in the upper and lower air by means of net-traps hung from the cables of barrage balloons at Cardington Airfield in Bedfordshire, with the excellent co-operation of the staff. Nearly every day in the summer, and also on many nights, balloons were flown with a series of traps at intervals up to 2,000 ft., or occasionally to 4,000 ft. The numbers of small insects caught were surprisingly great; on some hot summer days as many as twenty Aphidæ per hour were caught in a single net about three feet across and about 2,000 ft. above the ground. Since only a microscopic proportion of the air passes through the nets, the number of small insects at about this level must be enormous. All the insects were alive and apparently uninjured, and when they again fall to the ground, they could continue to lay eggs and start colonies or outbreaks of pests.

The nets hanging from the cables suffer from the disadvantage that the amount of air sampled varies with the wind velocity, and when the air is calm, as is often the case during the night, few or no insects are caught; but this is no proof of the absence of insects from the air. To overcome this difficulty, Dr. Johnson has developed a suction trap in which a fixed amount of air is blown through a vertical net by an electric fan. The volume of air thus sampled is independent of the wind velocity, at least up to wind speeds of about fifteen miles per hour, and so the results can be expressed as numbers of insects per 1,000 cubic feet of air, and become capable of mathematical treatment and comparison. Using these traps at ground-level, a very definite diurnal periodicity in the number of Aphidæ in the air has been shown to exist. There are one or two peaks during the day and very small numbers at night. It is hoped next year to have these traps attached to the barrage balloons, and so to get a correct estimate of the relative numbers of insects during day and night at the higher levels. This work is being carried out at Rothamsted with special reference to the long-distance distribution of injurious Aphidæ and particularly the black fly of beans (*Aphis fabæ*).

The last paper of the series was a description by Mr. P. S. B. Digby of a wind tunnel constructed recently for the experimental study of flight behaviour of insects. In this instrument wind speed, light, temperature and humidity can all be independently controlled, and the insects can be kept under direct observation during the tests. The criterion used is the rate of wing-beat of the insects as measured by a stroboscopic technique.

In the discussion which followed, the effects of turbulence and convection currents, and the difference between them over land and over sea, were considered by various speakers; the general conclusion was that insects are likely to gain height during the day-time over the land, and to fall steadily both by night over the land, and by day and night over the sea. There might, however, be a cushioning turbulence effect near the surface of the sea, which would prevent the majority falling into the sea under normal conditions. Heavy rain at sea, however, would bring down a large proportion of the aerial population.

C. B. Williams

NEWS and VIEWS

Nobel Prize for Physics for 1949: Prof. H. Yukawa

Prof. H. Yukawa, who has been awarded the Nobel Prize for Physics for 1949, is best known for his theory of nuclear forces which, in 1935, first postulated the existence of a particle a few hundred times heavier than the electron. The nuclear forces would then bear the same relation to the possible emission and absorption of such a particle as the electromagnetic forces in an atom bear to the emission and absorption of light. The discovery of the meson in cosmic rays appeared to be a confirmation of Yukawa's prediction, but the study of its properties gradually led to the conviction that it could not be identical with the particle required for Yukawa's theory. It was not until 1947 that Powell and his collaborators demonstrated the existence of a second short-lived particle, the π-meson, which is known to be the parent of the cosmic-ray meson, and which is strongly linked to protons and neutrons. This provided a brilliant vindication of Yukawa's idea. The detailed theory of the relation between this particle and the nuclear forces is still in its infancy; but, whatever the outcome, all thought about nuclear forces for the past decade and for many years to come is entirely dominated by the ideas of Yukawa. Since this first pioneer work, Yukawa has contributed much to other problems in fundamental theory and has built up an important school of theoretical physicists. As the editor of the new journal, *Progress of Theoretical Physics*, he has helped to provide an outlet for the great wealth of important contributions from his own school, as well as that of his colleagues. This new journal has already found a prominent place in literature on modern fundamental quantum theory.

Aeronautics at the University of Glasgow: Prof. W. J. Duncan, F.R.S.

Prof. W. J. Duncan, who has been appointed to the new Mechan chair of aeronautics and fluid mechanics in the University of Glasgow, is the son of a Glasgow shipbuilder, and, after completing his education at Dulwich College and University College, London, he spent seven years in his father's firm. He then joined

the Aerodynamics Department at the National Physical Laboratory, where he stayed for eight years. There, in collaboration with R. A. Frazer, and later A. R. Collar, he laid the foundations of aeroelasticity, treating the new subject of aeroplane flutter from both the theoretical and experimental aspects. When the Department of Aerodynamics was established at University College, Hull, in 1934, Duncan was asked to become its first head, and in 1938 he was made Wakefield professor in the College. He was building up what promised to be an important school of aeronautics at Hull when the Second World War broke out, and he went to the Royal Aircraft Establishment to help in the war effort. He was engaged in researches on aerodynamics and armaments and was for a time sent to Exeter to take charge of the Armaments Development Research Department there. At the end of the War he spent some time as chief scientist at Völkenrode, studying the work which the Germans had carried out. Prof. Duncan joined the College of Aeronautics at its inception and has been responsible as professor of aerodynamics for building up the teaching methods and the experimental equipment in the Department. He is a member of the Aeronautical Research Council and chairman of its Aerodynamics Committee, besides serving on several other committees and subcommittees of this body. His main interests lie in aerodynamics and advanced dynamics, and his original work in these fields brought him the honour of election to the Royal Society in 1947. Apart from these special predilections, he has a very wide interest in general engineering, and experience of considerable variety, added to which he is a very able mathematician. His loss to the College of Aeronautics next year will be a severe one; but the University of Glasgow will gain a man of science and teacher of outstanding ability.

British Museum: Sir John Forsdyke, K.C.B.

Permission has been granted by H.M. the King to Sir John Forsdyke to resign his appointment as director and principal librarian of the British Museum, as from March 31, 1950. He entered the Department of Greek and Roman Antiquities of the Museum in 1907, and was appointed keeper in 1932, having served in the Royal Artillery in the First World War. He took an active part in the preparation of the first volume of the Catalogue of "Greek and Etrurean Vases", and in 1909 published a paper in the *Journal of Hellenic Studies* which went far to determine the significance of the 'Minyan' fabric of pottery from prehistoric sites in central Greece. Under the leadership of Sir Arthur Evans, he excavated Minoan tombs near Knossos; and he gave to the British Academy a valuable lecture on Minoan art.

Appointed to the directorship of the British Museum in 1936, he became responsible for the planning and erection of the new Duveen Gallery for the Elgin Marbles. But the War made it necessary to place these and other principal collections in a place of security, and the bomb-damage to a section of the Library further diverted his energies. At the earliest possible moment, however, the new King Edward VII Gallery was devoted to a compendious but amazing sample of the Museum's treasures, including the recently acquired Saxon burial-find from Sutton Hoo. Outside the Museum, Sir John Forsdyke has been secretary of the Hellenic Society, and for a while editor of its *Journal*. He has also taken an active interest in the Byzantine Research and Excavation Fund, and the British School of Archæology at Athens. It is to be hoped that his retirement at no advanced age will enable him to devote himself both to these and similar administrative interests, and to the many aspects of classical archæology with which he has been concerned in the Museum.

Physical Society: Rutherford Memorial Lecture

The fourth Rutherford Memorial Lecture of the Physical Society will be given by Dr. Ernest Marsden on December 14, at 5 p.m., at the Science Museum, Exhibition Road, London, S.W.7. Dr. Marsden was formerly professor of physics at Victoria University College, Wellington, and until recently secretary of the New Zealand Department of Scientific and Industrial Research; he is at present in London acting as scientific adviser to the High Commissioner of New Zealand and to the New Zealand Government. Dr. Marsden was closely associated with Rutherford in the experiments leading to the conception of the nuclear theory of atomic constitution and also in those leading to the demonstration of the disintegration of nitrogen by α-particles; he has collected much information on the early family and student life of Lord Rutherford in New Zealand. His lecture will deal with some of these early memories and will show how Rutherford's inspiring personality influenced his research staff. A film will be shown entitled "Transformation of Elements", demonstrating the early experiments which led to the idea of the nuclear atom.

Sir Henry Savile, 1549–1622

November 30 marks the four hundredth anniversary of the birth of Sir Henry Savile, the founder of the Savilian professorships of geometry and astronomy at Oxford, the first of such chairs founded in the English universities. Born at Over Bradley, near Halifax, Yorks, he was educated at Brasenose and Merton Colleges, Oxford, and after gaining his degree read some public lectures on Euclid and Ptolemy. In 1578 he travelled abroad and on his return was made tutor in Greek to Queen Elizabeth. From 1585 onwards he was Warden of Merton College, and from 1596 also Provost of Eton College. A scholar and a patron of learning, he published some fine editions of ancient authors, wrote on various subjects, and, like his friend Thomas Bodley, was a generous benefactor of the University of Oxford. He died at Eton on February 19, 1622, and was buried there, a memorial being erected in Merton College chapel. His quater-centenary will be marked by lectures by Prof. H. W. Garrod, at Eton on November 27 and at Merton College on November 30. An article on p. 899 of this issue recalls some of the distinguished men who have held the Savilian chairs.

Portrait of Fox Talbot

An appeal for funds for a portrait of William Henry Fox Talbot has been issued over the signatures of Sir Robert Robinson, president of the Royal Society, Lord Brabazon of Tara, president of the Royal Institution, and Mr. Percy W. Harris, president of the Royal Photographic Society. Fox Talbot's researches between 1834 and 1841 place him in the forefront of photographic pioneers, for, from the results of these scientific discoveries, all photographic technique has since developed. The home of the Talbot family for many centuries has been Lacock Abbey, in Wiltshire, and this was presented to the

National Trust in 1944 by his granddaughter, Miss M. T. Talbot. On its walls are portraits of a number of Fox Talbot's ancestors; but there is no portrait of Fox Talbot himself. The hundred and fiftieth anniversary of his birth will occur in February 1950, and a fund has therefore been opened to commission a portrait in oils for the South Gallery of Lacock Abbey opposite the window which was the subject of the earliest existing photograph, taken by Fox Talbot in 1835 and now in the Science Museum, London. A portrait of this character is considered to be preferable to a photograph, so as to accord with the others in the gallery. The honorary treasurer of the fund is Mr. Harold White, and donations should be sent to him at the Royal Photographic Society, 16 Princes Gate, London, S.W.7, and made payable to the "Fox Talbot Portrait Fund".

Use of Glass Apparatus in the Laboratory and in Industry

THE past fifteen years have seen a revolution in the uses of glass apparatus both in the laboratory and in industrial plants. In particular, the adoption in the laboratory of standardized ground-glass joints has provided an alternative to old arrays of corks and rubber tubing. Quickfit and Quartz, Ltd., started to produce such equipment in 1934 on the initiative of Sir Graham Cunningham, chairman of Triplex Safety Glass Co., and until 1946 the works were wholly situated in the factory of the Triplex Co. at King's Norton, Birmingham. Quickfit and Quartz, Ltd., made gradual headway until 1939, and then, with the advent of the War, the abrupt cessation of laboratory supplies from Germany coupled with the greatly increased needs of research caused the output to go up ten-fold. Further expansion at King's Norton being impossible, in 1946 a new works was started at Stone in Staffordshire, which is now in production, and extensions are contemplated. With large pieces of glassware the question of annealing is extremely important, and special continuous-tunnel annealing-chambers are used, with polariscopes for viewing the strain contours by polarized light. The adoption by industry of glass for use in engineering plant was almost entirely a war-time development; but the value of glass in large condensers, heat-interchanges and for piping corrosive liquids, etc., is now universally recognized. Besides its use in the laboratory, glass has definitely taken its place as an important material in the whole field of engineering. The shop for production of industrial plant at Stone is only in part production, and the bulk of this work is still done at King's Norton.

Journal of Experimental Botany

THE *Journal of Experimental Botany* has been founded by the Society for Experimental Biology to provide a medium for the publication of original research in plant physiology, biochemistry and biophysics and in such related fields as experimental agronomy. The editorial committee consists of Prof. E. Ashby, Prof. T. A. Bennet-Clark, Prof. G. E. Blackman, Dr. R. Brown, Prof. F. G. Gregory, Dr. W. O. James, Prof. W. H. Pearsall, Dr. R. D. Preston and Prof. M. Thomas. The *Journal* will not be restricted to papers submitted by members of the Society, and contributions from research workers, both in Great Britain and abroad, will be considered. Manuscripts of papers submitted for publication should be addressed to the executive editor, Prof. T. A. Bennet-Clark, University of London, King's College, Strand, London, W.C.2. Three numbers will comprise a volume, and they will appear at four-monthly intervals, commencing in January 1950. The subscription price for three consecutive numbers is 35*s*., including postage. Single number 14*s*. net.

Sugar Research Foundation: Awards

THE fourth (1949) annual award of 5,000 dollars by the Sugar Research Foundation, Inc., New York, established by the Foundation to stimulate scientific studies of sugar as a food and as an industrial raw material, with the aim of improving its usefulness, has been made to Dr. Hermann O. L. Fischer, of the University of California, Berkeley, for his contributions to knowledge of the molecular structure of carbohydrates and his studies of glyceraldehyde, inositol and the nitromethane synthesis. Following the four annual awards of 1946–49 a grand prize of 25,000 dollars will be given in 1950 for the most significant discovery of the preceding five years. This prize will be awarded in recognition of discoveries, inventions or developments in the scientific or technological application of carbohydrates which contribute most significantly to an understanding of the functions of sugar (that is, sucrose), or its practical utilization, as a foodstuff or in its use in any other field of human activity. The award is open to any person, including the recipients of the four annual awards, and all entries should be submitted by February 1, 1950. Further details can be obtained from the Executive Secretary, National Science Fund of the National Academy of Sciences, 2101 Constitution Avenue, N.W., Washington 25, D.C.

Exhibition: Medicine in History

AN exhibition entitled "Medicine in History" will be opened on November 26 at the Glasgow Art Gallery and Museum, and will continue until the end of January. The exhibition will mark the three hundred and fiftieth anniversary of the Royal Faculty of Physicians and Surgeons of Glasgow, founded by King James VI on November 29, 1599, by a charter granted to Peter Lowe and Robert Hamiltone. Special emphasis has naturally been laid upon the work of medical men who were Fellows of the Faculty, among whom may be mentioned William Cullen, Joseph Black, William Hunter, Lord Lister, Sir William Macewen and David Livingstone. Through the courtesy of a Glasgow firm, a reconstruction of a modern operating theatre has been arranged, for contrast with that of an operating theatre in the Glasgow Royal Infirmary in the late nineteenth century. The advances made in radiology in the same space of time are also illustrated. The history of dentistry is traced in examples lent by a Glasgow dentist, and a London collector has loaned pharmacy jars and apothecaries' mortars. The foundations of modern medicine can be seen in a series of historical medical books. The exhibition has been made possible through the generosity and co-operation of institutions and private persons in Glasgow, Edinburgh and London in placing their valuable, and often irreplaceable, records and specimens at the disposal of the Corporation of the City of Glasgow.

Colonial Service: Recent Appointments

THE following appointments in the Colonial Service have been recently announced: J. Chattaway, agricultural officer, Federation of Malaya; W. R. Mills, agricultural chemist, Uganda; C. C. Shapland, agricultural officer, Tanganyika; J. R. Scobie,

lecturer in mathematics, Technical Institute, Yaba, Nigeria; W. M. Bagshaw, assistant conservator of forests, British Guiana; J. M. Boyce and R. P. Farrer, assistant conservator of forests, Tanganyika; I. Brett, assistant conservator of forests, Northern Rhodesia and Nyasaland; G. W. G. Cottle, assistant conservator of forests, Fiji; A. E. G. Storrs, assistant conservator of forests, Gold Coast; K. W. Trenaman and G. H. S. Wood, assistant conservators of forests, Uganda; B. H. Baker, P. V. Caswell and J. M. Miller, geologists, Kenya; J. V. Buller, geologist, Sierra Leone; C. G. B. Du Bois and R. J. Johnson, geologist, Uganda; M. S. Garson, geologist, Nyasaland; J. Hamilton and G. Henderson, geologists, British Guiana; G. Jefford, mineralogist–chemist, Tanganyika; D. W. Powell, geologist, Water Development Department, Tanganyika; A. M. M. Spurr, geologist, Tanganyika; F. J. H. Adcock, W. G. Midowicz and P. Peterson, assistant meterologists, Federation of Malaya; A. R. Green, veterinary officer, Tanganyika; G. J. Hawkins, ranger (fisheries statistician), Department of Game and Tsetse Control, Northern Rhodesia; R. T. Jarman, meteorological forecaster, Bermuda; F. I. Parnell, assistant director, Department of Game and Tsetse Control, Northern Rhodesia; I. G. Watterston and G. S. Young, provincial tsetse officer, Tanganyika; W. A. Stuart Williams, government statistician, Nigeria; P. C. Chambers (senior agricultural officer, Kenya), director of agriculture, Cyprus; R. G. Heath (senior agricultural officer, Federation of Malaya), chief field officer, Federation of Malaya; W. J. M. Irving (senior agricultural officer, Uganda), assistant director of agriculture, Uganda; J. C. Muir (director of agriculture, Tanganyika), member for agriculture and natural resources, Tanganyika; C. C. Skeete (director of agriculture, Windward Islands), director of agriculture, Barbados; F. H. Fitch (geologist, Federation of Malaya), senior geologist, Federation of Malaya; C. Raeburn (director of geological survey, Nigeria), commissioner on special duties, Nigeria; H. D. Tonking (senior pathologist, Mauritius), pathologist, Nigeria; H. M. Stuchbery (senior veterinary officer, Tanganyika), deputy director of veterinary services, Nyasaland; H. M. Johnston (malaria officer, Jamaica), malariologist, Jamaica.

The Night Sky in December

FULL moon occurs on Dec. 5d. 15h. 13m., U.T., and new moon on Dec. 19d. 18h. 55m. The following conjunctions with the moon take place: Dec. 12d. 23h., Saturn 0·3° S.; Dec. 13d. 09h., Mars 0·6° N.; Dec. 20d. 23h., Mercury 3° N.; Dec. 22d. 08h., Jupiter 4° N.; Dec. 22d. 23h., Venus 4° N. In addition to these conjunctions with the moon, Venus is in conjunction with Jupiter on Dec. 7d. 03h., Venus being 2° S. Mercury is unfavourably placed for observation during the first part of the month, but at the end of the month the planet sets 1h. 20m. after sunset and can be seen in the western sky for a short time. Venus sets more than three hours after the sun during December and is conspicuous in the western sky, attaining its greatest brilliancy (stellar magnitude −4·4) on Dec. 26. On this date the visible portion of the illuminated disk is only 0·26, but the planet is then only 38 million miles from the earth. Mars rises about midnight up to the middle of the month and at 23h. 27m. at the end of the month and can be seen in the morning hours in the constellation of Virgo fairly close to β Virginis about the middle of the month. Jupiter sets at 19h. 35m., 18h. 55m. and 18h. 13m. at the beginning, middle and end of the month, respectively, and is easily seen, lying low in the constellation of Capricornus. Saturn rises soon after midnight on Dec. 1 and at 22h. 17m. on Dec. 31, on which date it is stationary, and can be seen a little east of σ Leonis. Occultations of stars brighter than magnitude 6 are as follows: Dec. 3d. 22h. 53·6m., τ Arie. (*D*); Dec. 6d. 17h. 52·1m., 136 Taur. (*D*); Dec. 6d. 18h. 46·7m., 136 Taur. (*R*); Dec. 8d. 5h. 14·9m., 47 Gemi. (*R*); Dec. 9d. 0h. 32·4m., ω Canc. (*R*); Dec. 23d. 16h. 43·9m., ϰ Capr. (*D*); Dec. 25d. 17h. 10·6m., χ Aquar. (*D*); Dec. 31d. 19h. 18·0m., 104 B. Taur. (*D*). *D* and *R* refer to disappearance and reappearance, respectively, and the latitude of Greenwich is assumed. Winter solstice occurs on Dec. 22d. 04h.

Announcements

AT the forthcoming meeting of the American Association for the Advancement of Science, to be held in New York during December 26–31, the British–American Association Lecture (founded in 1938) will be delivered by Prof. G. B. B. M. Sutherland, lately of Cambridge and now professor of physics in the University of Michigan. The Lecture will be on "The Growing Importance of Infra-Red Studies in Physics, Chemistry and Biology". Dr. W. A. Macfarlane, of the United Kingdom Scientific Mission in Washington, will give a talk on the organisation of science in Great Britain.

MR. J. R. BARROWMAN has been appointed lecturer in agriculture and farm director, University of Leeds, from January 1, 1950.

THE Council of the University of Sheffield has decided that, in view of their distinction in research and scholarship in their several fields of study, the title of reader be conferred on: W. H. Wilcockson, senior lecturer in geology; Dr. T. S. Stevens, senior lecturer in organic chemistry; Dr. A. S. C. Lawrence, senior lecturer in physical chemistry, to be reader in colloid chemistry.

MISS JETTA M. TROTTER, of the University of Otago, has been appointed a lecturer in the Department of Education of the International Wool Secretariat, Dorland House, 18–20 Regent Street, London, S.W.1. Miss Trotter took her degree in textiles and household science, and also qualified as a teacher. She has spent much time in New Zealand on sheep farms and has also acquired a knowledge of wool marketing problems at various wool-selling centres.

THE Seventh International Botanical Congress will be held in Stockholm during July 12–20, 1950. Communication No. 3 from the Organising Committee, containing information on time of final application, membership fee, costs of excursions, expenses in Sweden, visa and money regulations, etc., is now being distributed. It can be obtained from the Secretary-General, Dr. Ewert Åberg, Uppsala 7, Sweden.

CHRISTMAS lectures for boys, primarily between the ages of thirteen and seventeen, are being arranged by the Institution of Civil Engineers. The first will be given by H. Shirley Smith, on "The Wonders of Big Bridges", on December 30, at 3 p.m.; the second will be given by C. W. Knight, on "The Building of Dams", on January 2. Applications for tickets, which are free, should be made to the Secretary of the Institution, Great George Street, London, S.W.1.

OXIDATION OF IRON IN THE RANGE 100–400° C.

FOR many years investigations into the films formed during the oxidation of iron have been proceeding in two corrosion laboratories, situated respectively in the Chemical Research Laboratory at Teddington and the Department of Metallurgy, University of Cambridge. Recently two pieces of work, undertaken quite independently but almost concurrently, have had a similar objective, namely, the elucidation of certain phenomena in the oxidation of iron around 200° C. Although the methods employed have been different, the two sets of results are essentially complementary. The Teddington work on this occasion has been collaborative, conclusions based on electron diffraction technique having been contributed from the Metallurgy Division of the National Physical Laboratory. Since the Cambridge and Teddington results present pictures of the same subject as viewed from different angles, it has been thought convenient to print in juxtaposition the preliminary accounts of the two investigations which follow.

Investigations at Cambridge

Early film-stripping experiments by J. Stockdale at Cambridge[1] suggested that the oxide formed on abraded iron at low temperatures was greatly interlocked with the metal, whereas at higher temperatures the oxide film and metal were separated by a relatively smooth surface. Vernon's early researches at Teddington[2] indicated that oxidation of abraded surfaces below 200° C. showed two differences from that above 200°, since (1) obedience to the parabolic law ceased and (2) no interference colours appeared even after ample oxygen-uptake. Colours were, however, obtained below 200° on single crystals by Mehl and McCandless[3] and on polished surfaces by Winterbottom[4]. Two equations have been put forward to express the oxidation of various metals at low temperature where the parabolic law fails, but, despite much discussion[5–7], there is no general agreement regarding their theoretical basis. The present note endeavours to reconcile these diverse facts, especially explaining why Vernon's two phenomena occur at the same temperature, and to provide basis for the asymptotic growth law; the logarithmic law has been discussed elsewhere[8].

The line of thought was started by a microscopic study of films transferred at Cambridge by a combination of earlier methods[8,9]. The iron sheet, kindly provided by the British Iron and Steel Research Association, contained 0·02 per cent carbon, with 0·04 per cent oxygen as a magnetite network. In the main experiments, the metal was used in the as-rolled condition, degreased in xylene and/or acetone; but a number of experiments were carried out on specimens from which the original surface layers had been removed either by abrasion, anodic etching (in sodium-chloride/zinc-sulphate solution) or preferably by heating to produce a first-order interference tint, the oxide film being then destroyed by reductive dissolution with zinc and hydrochloric acid; in the latter method, the liquid was removed with de-watering oil, which was itself removed with xylene.

About two hundred and fifty specimens were heated to produce superficial oxidation, and the films were transferred to 'Vaselined' glass. A veil of magnetite was always found clinging to the oxide film, but in some cases it was easily removed by a water-jet. Thus iron tinted pale blue by heating 4·5 min. at 370° C. yielded on washing a clean, uniform ferric oxide film, recalling gold leaf; areas of the specimen which had been freed from oxide with zinc and hydrochloric acid just before transfer were represented after transfer by bare glass.

This easy removal of the veil is characteristic of the first-order films, but the 'invisible' film formed at low temperatures shows a strong adhesion to the veil particles. Gentle washing leaves the veil clinging to the film, while a powerful water-jet removes them both together. The adhesion suggests that the pre-existing magnetite serves as nuclei for the invisible film, but not for the colour-films. The higher temperature and longer time involved in producing colour-films will provide for the nucleation energy, whereas at low temperatures the transformation of iron containing oxygen in solid solution into oxide will occur readily only where oxide particles already exist, or where the atoms are in such disarray that the energy needed to form nuclei is exceptionally low.

The veil, if left in position, develops shrinkage phenomena, gathering into aggregates; this indicates that the internal magnetite network must have been *in tension*, probably as a result of rolling. On the thinner films, the change produces cracks in the ferric oxide layer; apparently the veil, as it shrinks, drags with it the firmly attached film. Fig. 1 shows the film taken from a specimen exposed to a temperature gradient (hot region at the top). The right-hand side was freed from veil before the shrinkage had occurred.

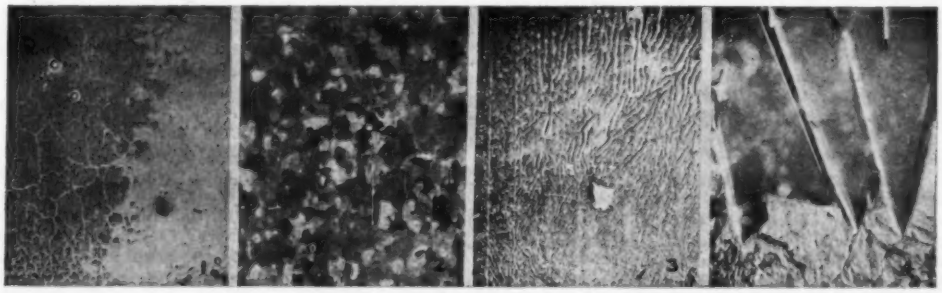

Fig. 1. Transmitted light, × 20 Fig. 2. Transmitted light, × 75 Fig. 3. Reflected light, × 4 Fig. 4. Reflected light, × 4

so that the transparent film remains uncracked. On the left, the veil was not removed, and a network of cracks has developed, penetrating the film; the 'mesh' of the network becomes smaller as the lower (thin-film) end is approached.

The film from iron showing a first-order colour consists essentially of ferric oxide with occasional clinging magnetite particles; the removal of these particles seems most difficult at the two ends of the first-order range. In the second-order range, a continuous magnetite layer appears below the outer ferric oxide layer, as found on other materials[8]; it is thin and transparent, and the duplex films viewed by transmitted light reproduce the grain structure of the metal (Fig. 2). The films show wrinkling (Fig. 3), indicating that the ferric oxide must have been in *compression* when on the metal. In the third-order region, the magnetite is thicker, and the duplex films curl into tight rolls (Fig. 4)—a phenomenon not noticed on other samples of iron. Apparently the oxide has grown inwards and incorporated part of the pre-existing magnetite network; the existence of two layers, respectively in tension and compression, must cause curling in the direction actually observed.

The observations suggest that oxidation extends *inwards*—which accords with the view long held by Valensi[10]—and that the oxide envelops inclusions which retain their internal stresses; the inheritance of internal stress by an oxide film was shown in earlier work on nickel[9].

Rhines[11], when studying copper–manganese alloys, showed that at low temperatures particles of manganese oxide appeared preferentially at grain boundaries, whereas at higher temperatures they appeared within the grains; doubtless the energy necessary for the transformation of oxygen-solid solution to oxide is least at the grain boundaries, which are places of disarray. Presumably on Vernon's iron, the spontaneous formation of fresh nuclei at the external surface was a frequent phenomenon above 200° C., leading to a film sufficiently uniform to produce interference colours and thicken by the parabolic law. Below 200°, there was probably insufficient energy for the formation of nuclei at typical points on the surface, so that oxidation started either at points where oxide nuclei existed already, or at places of atomic disarray, where the formation of nuclei would require comparatively little energy. Such local or internal oxidation would be unfavourable for interference colours and inconsistent with parabolic growth.

We see, therefore, why Vernon's two phenomena set in at the same temperature. On materials containing no internal point of disarray, nuclei would in time be formed at the surface, so that slow colouring would be expected even at low temperatures—as on Winterbottom's mirrors and Mehl's single crystals.

The interlocking of oxide and metal at low temperatures[1] shows that rapid oxidation only occurs at favoured points. Probably the paths along which oxidation penetrates represent lines of atomic disarray. The degree of disarray needed for penetration will increase as temperature drops, so that at low temperatures the number of paths will diminish as they extend (at higher temperatures bifurcation of some paths will compensate for the termination of others). If the chance of a path terminating in length-element dl is *defined as* kdl, the chance of the total length falling between l and $l+dl$ will be $\exp(-kl)\,.\,kdl$, so that the limiting weight-increase will be

$$N_0 \int_0^\infty \omega l \exp(-kl)\,.\,kdl,$$

where N_0 is the initial number of paths and ω the weight-increase associated with unit path-length. The integral possesses a finite value $(N_0\omega/k)$, so that, in absence of any other factor, there is a weight-increase which can never be surpassed, however long the experiment is continued. This may explain the asymptotic character of certain oxidation curves, and meets the main requirements of Lustman[7], who has questioned the tunnel-effect theory[8] on the grounds that "it predicts no temperature dependence of the constants". The existence of asymptotic growth laws is becoming increasingly recognized, notably by Champion[12].

The empirical equations supposed to hold in circumstances where the parabolic law fails are the non-asymptotic $W = k_1\ln(k_2t+1)$, and the asymptotic $W = k_1\{1-\exp(-k_2t)\}$. Provided that $k_2t<1$, the two equations, when expanded, only diverge at the third term,

$$W = k_1[k_2t - \tfrac{1}{2}k_2{}^2t^2 + \tfrac{1}{3}k_2{}^3t^3 - \tfrac{1}{4}k_2{}^4t^4 \ldots .]$$
$$W = k_1[k_2t - \tfrac{1}{2}k_2{}^2t^2 + \tfrac{1}{6}k_2{}^3t^3 - \tfrac{1}{24}k_2{}^4t^4 \ldots .],$$

so that sometimes a short-time experiment might give results consistent with either equation.

I would express my thanks to Mr. D. Whitwham for preparing the photomicrographs, and to Dr. J. N. Agar and Dr. J. E. O. Mayne for useful discussion.

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Investigations at Teddington (Oxidation of Iron around 200° C.)

An earlier investigation[1] on the oxidation of abraded mild steel sheet in air at atmospheric pressure revealed the existence of a 'critical temperature' at *c.* 200°. Thus (i) interference colours, the characteristic sequence of which is a function of film thickness above 200°, do not appear below 200°, although the corresponding oxygen uptake may be appreciably exceeded; (ii) oxidation – time curves, characteristically parabolas above 200°, show marked non-conformity below 200°; (iii) the temperature-coefficient curve shows an inflexion at *c.* 200°. Recent advances in film-stripping technique at the Chemical Research Laboratory having facilitated the study of films removed from the substrate, the opportunity has been taken to investigate the phenomenon more closely. Films have been removed from mild steel

sheet heated for various times at 180° and 225°. The crystal structure, as observed by electron diffraction (work carried out in the Metallurgy Division, National Physical Laboratory), has been compared with the composition of the film as determined by chemical analysis, the relative thickness being assessed from the total iron content of the film.

The films have been stripped by the alcoholic iodine method[2], using specimens previously dipped in 'Formvar' (polyvinyl formal) resin. The oxide film is removed together with the thin resin backing and the reinforced film transferred to a wire grid for examination in the electron diffraction camera. For chemical analysis the films are dissolved in acid and the solution examined for ferrous and ferric iron.

The electron diffraction work was carried out on a Finch camera with the usual type of cold-cathode electron source and saturated diode stabilization. The films were examined both *in situ* on the metal surface by the reflexion method and by the transmission technique after stripping. At least two separate areas of each specimen were examined.

Confirming earlier work, there was no progression of interference colours at 180°, but at 225° the usual sequence of bright colours was observed.

Electron diffraction (reflexion and transmission) patterns showed that the films, both at 180° and 225°, consist of an outer layer of rhombohedral α-Fe_2O_3 overlying cubic oxide of composition between γ-Fe_2O_3 and Fe_3O_4. It follows, therefore, that the phenomenon in question cannot be associated with any major crystalline change in the film at the critical temperature. On the other hand, preliminary chemical analyses have yielded the remarkable result that, for films produced at 180°, the values of ferric and total iron are approximately constant over the range 20–453 hours of heating. It follows that over this range there is virtually no increase in the thickness of the film removed by stripping. On the reasonable assumption (for which previous work[2] provides evidence) that it is on this film that the development of interference colours depends, a simple explanation is forthcoming why such colours do not, in fact, develop. It remains, however, to explain why thickening of the film is suspended, notwithstanding that oxygen uptake continues, with progressive increase in the weight of the specimen.

At 225°, for all periods of heating, uptake of oxygen contributes directly to the thickening of the film, as shown by its total oxygen content. At the lower temperature, oxygen uptake in excess of that required to produce the strippable film must add to the content of iron oxide *beneath* the film, that is, in the immediately underlying 'mixed zone' ("iron oxide incorporated sporadically in a matrix of iron"[2]) or "zone of interlocking"[3]. Clearly, however, this can occur only *by the diffusion of oxygen inwards through the surface film* (in accordance with the views of Valensi[4]), in contradistinction to the accepted Wagner mechanism at the higher temperatures in which metal ions diffuse outwards through a defective lattice of the oxide.

The mode and rate of growth of the film must depend upon the relative rates of diffusion of (i) oxygen (whether as ions, atoms or molecules) through the outer rhombohedral zone, and of (ii) iron ions through the inner cubic zone. It is unlikely that the temperature coefficient will be the same for each of these processes. The evidence suggests that the curve for (ii) is steeper than that for (i) and that the two curves intersect at *c.* 200°. Thus, below 200° oxidation is propagated mainly by diffusion of oxygen inwards, above 200° by diffusion of iron outwards; on this view, the difference in the slopes of the respective (diffusion) temperature-coefficient curves accounts for the inflexion in the (oxidation-rate) temperature-coefficient curve that is experimentally observed at 200°. It is inherent in this argument that the relative diffusion rates will depend very appreciably upon the initial surface condition of the metal. Thus, the value of *c.* 200° is characteristic of polycrystalline surfaces prepared by careful abrasion (not 'polishing'). As mentioned in Dr. Evans's contribution, lower critical values have been reported for single crystals and for surfaces produced by polishing.

Furthermore, the diffusion of iron ions outwards through the lattice of the oxide film ($> 200°$) must produce new oxide on the outer interface; there is no reason to suppose that this could result in anything but a simple thickening of the film. The position is quite different with the reverse process ($< 200°$), since oxygen atoms arriving at the metal/film interface encounter a mixed assembly of metal matrix and (magnetic) oxide nuclei. It can readily be understood that oxidation will now proceed by the growth of pre-existing nuclei rather than by simple film-thickening. This conclusion is in substantial agreement with that reached, as the result of an entirely different mode of approach, by Dr. Evans in his accompanying contribution.

It remains to add that the 'veil' of magnetite described by Dr. Evans as clinging to his separated film is, in the Teddington film-stripping technique, left as a residue on the metal substrate when the film is removed. The distinction arises necessarily from the different experimental characteristics of the two methods. In each case, however, the material must incorporate the magnetic oxide 'nuclei' referred to in the two communications.

The foregoing is a preliminary account of work still in progress, the results from which will be published in greater detail elsewhere. We wish to express our indebtedness to Dr. F. Wormwell for helpful discussion.

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SCIENTIFIC RESEARCH IN THE RHODESIAS AND NYASALAND

A REPORT to the Central African Council on the Regional Organisation of Research in the Rhodesias and Nyasaland*, by Dr. J. E. Keyston, who is relinquishing his present position as research secretary under the Council towards the end of the year, has been considered by the Central African Council and by the three Governments. Although Dr. Keyston's main recommendation that a joint research council should be established has not been adopted, a Standing Advisory Committee for Research

* Central African Council. A Report on Regional Organisation of Research in the Rhodesias and Nyasaland. By Dr. J. E. Keyston. Pp. iv+91. (Salisbury: Central African Council, 1949.) 5s.

is to be appointed to devise means of mutual assistance between the territories in research activities, to advise on the priority of research needs and to prevent overlapping of effort. The work of this Committee will be much simplified by the report which Dr. Keyston has prepared.

Dr. Keyston's report is in three parts. The first consists of the survey of the present provision for scientific research in the Rhodesias and Nyasaland which, on account of the many deficiencies revealed, leads him to conclude that the essential element in effecting collaboration in research is a joint research council. Not only is there far too little research, and especially applied research, but also central organisation of research is lacking, and the support and control of research are too exclusively in the hands of Government. Co-operation between Government departments, commerce and industry is inadequate, there is waste of expenditure and staff and lack of long-term planning; there are no centralized services such as a scientific and technical information bureau and specialist library. Dr. Keyston also regards the conditions of service affecting research workers as unsatisfactory and the arrangements for guaranteeing the supply of scientific man-power as inadequate; nor is there sufficient co-operation in research with other countries. He discusses in some detail the problem of keeping research staff fresh in outlook, receptive of new ideas and techniques, self and mutually critical, and creative; and he stresses the contribution to this end which co-operation between the three territories, permitting the interchange and intermingling of staff, could make. He envisages in particular an arrangement between the three Governments and that of the United Kingdom to enable scientific workers in the Colonial Service, the Colonial Research Service or that of Southern Rhodesia to be seconded for service in any of the three Central African territories without loss of rights and benefits, and the appointment of staff on a joint Rhodesia–Nyasaland basis under the suggested research council.

The second part of the report outlines a suitable constitution for the proposed Rhodesia–Nyasaland Research Council, to which Dr. Keyston appends some notes on such a council as a corporate body; on co-operation between it and the Colonial Office on the choice of site for its headquarters, which he suggests should be at Salisbury; on the effect of pension provisions on the relative mobility of scientific men in the United Kingdom Government Scientific Civil Service and the Southern Rhodesia Government Service, in which the great advantages of the United Kingdom pension system are indicated; on the general pattern of Commonwealth scientific liaison; and on a Central African scientific library and a scientific information bureau for Government agencies in the Rhodesias and Nyasaland. The establishment of scientific information and liaison services would be one of the first tasks of the research council, others being the long-term planning of research and research facilities, the arrangement of partnerships between Government and industry (including agriculture) in the conduct and support of research, stimulation of the interest of local youth for training for research careers, negotiation of contracts for research assistance from organisations in other countries and encouragement and solicitation of research bequests and grants from private philanthropic sources.

The major part of the report is a survey of the most important research requirements of the Rhodesias and Nyasaland in which joint action can be recommended. In this Dr. Keyston reviews the different fields of science to illustrate the way in which co-operation in meeting these needs might be furthered by a Rhodesia–Nyasaland research council. In geodetic and topographical surveys, however, he points out that the present need is for separate action by Northern Rhodesia and Nyasaland to augment the efforts of the Colonial Geodetic and Topographical Survey. In regard to geological research, he recommends the establishment within the Department of Geological Survey at Salisbury of a Central African geophysical research station with at least five research officers, preferably as a research unit of the proposed research council, and close liaison and collaboration with the Geological Survey of the Union of South Africa is also recommended. The three territories already enjoy a joint meteorological service provided by the Southern Rhodesia Department of Meteorology; but Dr. Keyston directs attention to the desirability of establishing in Salisbury a Southern African meteorological research centre supported by contributions from all Southern African territories, and also urges the extension of the activities of the Salisbury Department of Meteorology in the collection of climatological data of interest in agricultural research and development. There is a need for a central group of hydrological experts to plan a more systematic collection of the water records now being taken, to investigate the broad scientific relations between water-level, water-flow, geological features, soil characteristics and meteorological conditions; and to promote research into such matters as the extent to which underground water supplies are being used up or replenished, the effects of forests, pastures, cultivation and various crops on evaporation, run-off and seepage, and the basic trends and causes of long-period variations in the levels of lakes and the area of marshes and swamps. He strongly urges the establishment of a Central African hydrological research group with at least six research officers.

In regard to agricultural research, the problem of organisation is how to recruit and deploy most rapidly sufficient research workers of high quality under able and flexible direction in conformity with a soundly planned strategy. He strongly advocates the establishment of a Central African ecological research unit under the proposed research council, and the council should also seek to foster the increased economy and efficiency which would result from joint use of the services of commodity experts by agricultural departments, as well as arrange co-operation in commodity research with external territories and establish research on a research association basis for the cultivation of any commodity which, like tobacco in Southern Rhodesia, assumes the magnitude of a major industry. Tea research in Nyasaland he would organise under a tea research association. Pasture and farming system experimental stations are required in every distinct vegetation-soil sub-division of agricultural importance in the territories. The one central research centre staffed to investigate fundamental pastoral problems required to serve Southern Rhodesian needs could simultaneously meet similar needs for Northern Rhodesia and Nyasaland. When given such Central African status and responsibility, the Southern Rhodesian Grassland Research Centre should remain an integral part of the Department of Agriculture, Salisbury, while the agricultural research committee of the proposed research council would be made advisory to the Secretary of Agri-

culture, Salisbury, for the broad programme of joint grassland research.

Dr. Keyston deals in some detail with the organisation of tobacco research under the suggested Rhodesia–Nyasaland tobacco research association. He advocates also the establishment on a Central African footing of an agricultural machinery experimental station which might possibly also serve South and East Africa. Stress is laid on the importance of soil science; for a Central African soil laboratory the Agricultural Chemical Laboratory of the Department of Agriculture, Southern Rhodesia, provides the obvious nucleus. One central laboratory is required with good facilities for plant breeding, pathological and physiological research, including some accommodation for fundamental plant research, and specifically in association with the new herbarium to be constructed at Salisbury there should be provided good laboratory and nursery facilities for plant genetical, pathological and physiological investigations, including accommodation for visiting research workers. The same herbarium should be planned and constructed as a Central African herbarium, offering to all those territories scientific facilities and amenities comparable with those which the Royal Botanic Gardens at Kew offer to the United Kingdom. Forestry research is of especial importance. While substantially all sylvicultural research should be organised within the forestry departments of the three territories, most research on the utilization of timber is regarded as appropriate for a Central African construction experiment institute. Establishment on the copper belt of a chemical research laboratory to undertake work on wood chemistry, the discovery of new products derived from natural vegetation, agricultural crops and wastes and industrial chemical research pertinent to the establishment of Central African industries is suggested. Entomological research should be supervised by a Central African entomological research committee of the council, and in particular a Central African tsetse survey team, visualized as a self-contained mobile unit, is recommended.

For veterinary research in Southern and Northern Rhodesia, it is suggested that the veterinary departments at Salisbury and Mazabuka should each establish a research unit of not less than four officers, and that satisfactory arrangements should also be made with the Department of Agriculture, Pretoria, and the East African Veterinary Research Organisation, to include Rhodesian interests; but there is as yet no need for participation by Nyasaland in joint arrangements. Dr. Keyston strongly recommends that Southern Rhodesia should base its organisation for fisheries investigation on participation in the fisheries research project already prepared by the Northern Rhodesia and Nyasaland Governments. He suggests that the research council should stimulate more research on the fauna of Central Africa and that a fauna research committee should be set up, though the recruitment of biologists for such research is not recommended. Strongly supporting the conclusions relating to medical research in Southern Rhodesia of the report of the National Health Service Inquiry Commission (1946), Dr. Keyston recommends the institution, under the proposed Rhodesia–Nyasaland research council, of a medical research committee and a Central African medical research staff under an experienced specialist as director with headquarters, including specialist library, at Salisbury. The maximum co-operation should be fostered between research and public health organisations, and arrangements made for interchange of staff annually between medical research authorities in the United Kingdom and the Union of South Africa and the new research centre. The programme of medical research should include disease surveys and nutritional surveys, while bilharziasis and malaria require special attention.

Sociological research directed towards assisting the administration is imperatively needed, and Dr. Keyston recommends the establishment of a Central African sociological research centre at Salisbury, whether or not this can be formed by re-siting and re-organising the Rhodes Livingstone Institute; and the programme of research should also comprise social experiment and fundamental sociological and anthropological studies. Besides all this, the report stresses the need for African personnel research, for which purpose a special research committee should be formed under the council, and the council should also be provided with statistical officers and with an operational research unit of at least six officers. To deal with buildings, roads and civil engineering works, a civil engineering research committee of the council is desirable as well as a co-ordinating committee for archæological and historical research and a museums board. On a rough estimate, Dr. Keyston puts the initial capital expenditure on the programme detailed in this third part of the report at £135,850, and the recurrent annual expenditure at £266,000; and a table is appended indicating the distribution of the expenditure between the different activities and the three Governments concerned. Scientific workers will note with appreciation the attention given throughout the report to conditions of service, which are clearly designed to prevent either staleness or the sense of isolation so detrimental to creative work.

UNIVERSITY AND RESEARCH SECTION OF THE LIBRARY ASSOCIATION

ANNUAL MEETING

THE University and Research Section of the Library Association held its annual conference at Carlyle Hostel, Edinburgh, during September 15–19. It was the first time that the Section had met in Scotland, and members took full advantage of the opportunity of visiting the many fine libraries and scholarly institutions in Edinburgh. The Section was welcomed by the principal of the University of Edinburgh, Sir Edward Appleton, at a reception in the Upper Library of the University. Sir Edward referred in his address to the spate of scientific literature confronting the research worker, and also urged the setting up of some central body to maintain a register of translations of papers originally written in unfamiliar languages.

Mr. R. Irwin, director of the University of London School of Librarianship, opened a discussion on training for university and research librarianship. He stressed the fact that the School course is a post-graduate course entirely, and urged university librarians to rely on the School for some, at least, of their trained recruits for permanent posts on library staffs. Mr. Irwin suggested that a starting salary of at least £350–£400 should be offered to the trained

graduate taken on by university libraries, with reasonable prospects of promotion. He mentioned that very few science graduates were coming forward as candidates for librarian posts, and during the discussion it was pointed out that a science graduate is perhaps not likely to be attracted by a salary of £350 when he can probably command more than that immediately upon taking his degree. Some scientific libraries seem willing to take graduates in other than scientific subjects.

The programme also included an address by Dr. H. W. Meikle, chairman of the Edinburgh University Library Committee, who gave a historical account of the libraries of Edinburgh; and a paper on the present condition and organisation of some of the libraries of northern Italy was read by Dr. W. Bonser, librarian of the University of Birmingham. Dr. Douglas Guthrie, lecturer on the history of medicine in the University of Edinburgh, spoke to the Medical Section on the evolution of medical studies in Scotland.

An important discussion on the future policy of the Section and its role within the Library Association was keenly followed by members present. Visits were paid to the National Library of Scotland, the Signet Library, the University Library, the City Library, and the Libraries of New College and the Royal Society of Edinburgh. The Medical Section inspected the University Medical Library and the Royal College of Physicians, while another party went to the Commonwealth Bureau of Animal Breeding and Genetics, and the small but pleasantly designed library of the Zoological Department of the University. This strenuous but interesting week-end was completed by a brief visit to Glasgow to inspect the University Library and the Royal Faculty of Physicians and Surgeons.

MARINE BIOLOGY

THE first number of Volume 28 of the *Journal of the Marine Biological Association* contains twelve papers of interest to varied workers in this field.

Dr. F. Gross and Prof. J. Raymont describe two aspects of the results of fertilizing Loch Craiglin, an experiment which has been going on now for seven years. The records show considerable fluctuation, and even with small quantities of added fertilizer there is a disturbance in the natural balance of organisms, which may, over a period of years, affect the fauna detrimentally from the human point of view. Some of these results are unexpected. Thus, growth in size of the invertebrate population may be stimulated to such an extent that there is not sufficient small food available for young or for small-mouthed fishes such as the Pleuronectids. Prof. Raymont reports at least a hundred per cent increase in the bottom fauna; but does not find evidence of decrease in availability as fish food. The fish records, on the other hand, were disappointing, and Dr. Gross considers that unfavourable hydrographic conditions reduced the growth-rate, despite favourable feeding conditions. This led him to the conclusion that sexual maturity in flounders is correlated with size, not with age.

Five papers on the biology of marine organisms deal with *Tubularia*, copepods, *Asterias*, flagellates and sand eels. Those who have seen the handsome colonies of *Tubularia larynx* settled on rafts moored in the Firth of Clyde, in connexion with research on anti-fouling at the Millport Marine Biological Station, will welcome the interesting account by Messrs. Pyefinch and Downing of the biology of this species. The rapidity of settlement of the actinula larva after extrusion from the gonophore of the parent, and the production of actinulæ from the settled polyp, twenty-four days after settlement, account for the crowded colonies of this beautiful Cœlenterate.

Dr. Sheina Marshall continues her work on copepods by a study of seven species occurring in Loch Striven. All produce successive broods throughout the summer and, with the exception of *Microcalanus pygmæus*, show a seasonal vertical migration. The food of the copepods was studied, and it was found that *Centropages* and *Temora* are not dependent on diatoms entirely, but feed on small animals as well, while *Microcalanus* and *Oithona* subsist largely on flagellates. These feeding habits will affect the relative distribution of the species at different times of the year.

The cannibalistic habits and tenacity of life of starfish, their rate of growth and the correlation between food and breeding rather than between size and breeding were worked out by Mr. H. G. Vevers. It is not possible to determine the age of a starfish.

Dr. Mary Parke describes the specific characters and life-histories of the six minute flagellates used as food for oyster larvæ in the Port Erin oyster-rearing experiments, and her paper is illustrated by coloured plates.

Messrs. P. G. Corbin and Vidya Vati have worked out the post-larval stages of the three common sand eels, and have added a fourth from the Plymouth area, to which at present they give no name. Adult *Gymnammodytes semisquamatus* have been found in the region, but not, so far, the young.

A systematic study of the marine and brackish water rotifera of Plymouth has been made by Mr. E. D. Hollowday. There must be many biologists who have found rotifers in the plankton or among weed, and have been unable to identify them. Now there is no excuse, so far as these six species, illustrated by fine drawings, are concerned.

An ecological survey of the Exe Estuary is described by Mr. N. A. Holme. The erosion of Dawlish Warren is shown by aerial photographs taken in August 1945 and April 1946, and even in the short period of eight months a considerable portion of the sand-bank known as Warren Point has been washed away, causing redistribution of the sand, but with little effect on the physical conditions or the estuarine fauna. The species of plants and animals are listed relatively to the substratum of pure sand, muddy sand, and mud with *Zostera*. Mr. Holme concludes that soil drainage affects the fauna more than any other factor.

Mr. G. Chapman contributes a biophysical paper on the thixotropy of a marine soil, in relation to the burrowing speed of *Arenicola marina* L. on the Whitstable flats (see *Nature*, December 4, 1948, p. 894). Dr. H. W. Harvey has estimated the amount of manganese available in sea-water off Plymouth at about 1·0 mgm. manganese/m.^{3}, and off the Isle of Man at more than 2·0 mgm./m.^{3}, the latter area being capable, therefore, of supporting a much richer summer population of flagellates. In fresh-waters the amount is still higher and may attain 40 mgm./m.^{3} in agricultural areas.

Finally, Dr. J. P. Harding describes how probability paper can be used for the graphical analysis of polymodal frequency distributions, a useful contribution for statistical biologists.

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

Structure of Dinitrogen Tetroxide

As the structure of the dinitrogen tetroxide molecule has recently been the subject of discussion[1], it may be of interest to record the following measurements, obtained from an X-ray study of single crystals of this compound. Previous diffraction work has been recorded by Vegard[2] and re-interpreted by Hendricks[3], but as this was confined to powder specimens the evidence is not conclusive.

In our present work, single crystals slowly crystallized from the gas were sealed into very thin-walled glass capillary tubes. These were maintained at a temperature of $-40°$ C. by means of a current of cold dry oxygen gas while being set and photographed on a Weissenberg type of X-ray spectrometer. Using copper $K\alpha$ radiation, complete rotation and oscillation photographs were obtained about the principal axes and diagonals of the unit cell.

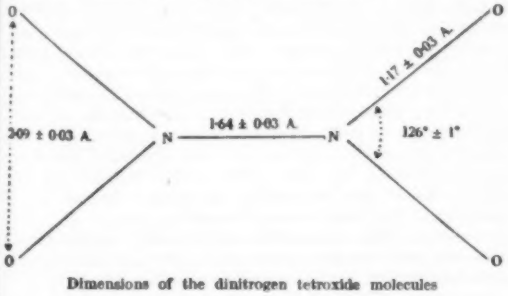
The system is apparently cubic, with $a = 7{\cdot}77 \pm 0{\cdot}01$ A., and the unit cell contains six molecules of N_2O_4 (density, measured, is 1·90–1·98, and calculated, 1·95 gm./c.c.). These results are in good agreement with previous work.

With regard to the space group, the absent spectra and observed intensities indicate $I_{2,2,2}$, $I_{2,2}$ or I_{m2}. There is no direct experimental method of distinguishing between these groups, but other evidence points to I_{m2}. This space group was therefore assumed, and the choice is justified by our subsequent analysis.

Intensities of reflexions from two zones, the principal axis and the body diagonal, were estimated from moving-film records, employing the multiple film technique[4]. About 75 per cent of the possible reflexions were actually observed.

A trial model, based on a centrosymmetrical molecule, gave reasonable agreement between calculated and observed structure factors, and the structure was then further refined by the double Fourier series method. In the final electron density maps, the atoms are fully resolved and their position can be estimated with considerable precision.

The twelve nitrogen atoms are found to occupy the twelve special positions of the space group, and the twenty-four oxygen atoms the twenty-four special positions, with the following parameters, $x = 3{\cdot}06$ A., $y = 2{\cdot}53$ A., $z = 1{\cdot}04$ A. This leads to the molecular structure and dimensions shown in the accompanying diagram, where all the atoms lie in the one plane. On this basis, the average discrepancy between the calculated and observed F values is about 16 per cent for all the reflexions observed.



Dimensions of the dinitrogen tetroxide molecule

A point of special interest lies in the unusually long nitrogen – nitrogen bond of 1·64 A., the distance in hydrazine being about 1·47 A. The other bond-lengths and angles, being near the expected values, receive support from other investigations.

In conclusion, we would like to express our thanks to Dr. R. I. Reed for his interest in the work, and to Mr. R. McCulloch for help in building the complicated apparatus required.

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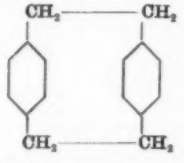
July 13.

[1] Ingold, C. K., and Ingold, E. H., *Nature*, **159**, 743 (1947).
[2] Vegard, L., *Z. Phys.*, **68**, 184 (1931).
[3] Hendricks, S. B., *Z. Phys.*, **70**, 699 (1931).
[4] Robertson, J. M., *J. Sci. Instr.*, **20**, 175 (1943).

Preparation and Structure of Di-*p*-Xylylene

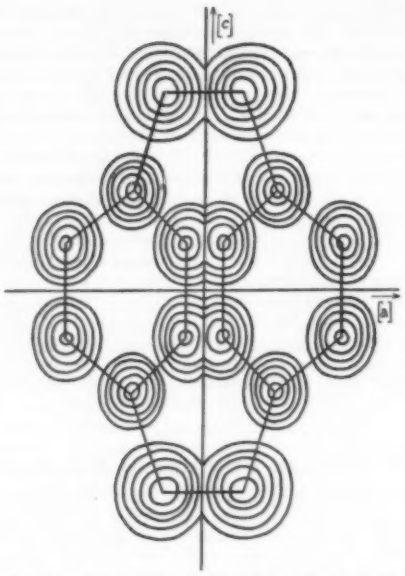
Polymerization products from *p*-xylene have been shown to contain, *inter alia*, a hitherto undescribed hydrocarbon, the novel structure of which has been determined solely by X-ray diffraction to be tri*cyclo* [8 : 2 : 2 : $2^{4,7}$] hexadeca-4 : 6 : 10 : 12-(1) : 13 : 15-hexaene. We propose as a suitable trivial name 'di-*p*-xylylene'.



We have examined polymers made in these Laboratories by Messrs. Gill and Lord by the low-pressure pyrolysis of *p*-xylene using the technique described by Szwarc[1]. Extraction of the polymer with chloroform in a Soxhlet apparatus yielded a mixture of low molecular-weight compounds. This extract contained traces of an acetone-insoluble fraction, having m.p. 285° after re-crystallization from pyridine or glacial acetic acid. (The acetone-soluble fraction is being examined further.)

The crystals were found to be tetragonal, with $[a] = 7{\cdot}82$ A., $[c] = 9{\cdot}33$ A., space group $P4/mnm$-D_{4h}^{14}, and with two molecu. to the unit cell. Further analysis, employing X-ray intensities from about 300 planes in appropriate Patterson and three-dimensional Fourier syntheses, showed the structure to be that of di-*p*-xylylene, as represented by the accompanying electron density diagram. The dimensions of the molecule are interesting. The three C—C aliphatic bond lengths are 1·54, 1·55 and 1·54 A., and the C—C bond lengths in the benzene rings are all 1·40 A., but the benzene rings are not quite flat. The two substituted carbon atoms in each benzene ring are each displaced from the plane of the other four by 0·13 A., presumably to relieve the strain in the system. The distance between the pairs of four unsubstituted carbon atoms is 3·09 A., and that between the substituted carbon atoms is 2·83 A. The angle between the bonds at the aliphatic carbon atom is 114½°.

This new hydrocarbon is analogous to *s*-dibenz*cyclo*octadiene (di-*o*-xylylene) described by Baker,



Composite three-dimensional electron density map of di-*p*-xylylene

Mann *et al.*[2]. Attempts to prepare di-*p*-xylylene by standard organic chemical methods have not been successful, and it is possible that the strained system may only be formed under drastic pyrolysis conditions and low pressures.

A fuller description of the properties and structure determination of this new hydrocarbon will be submitted for publication in the *Journal of the Chemical Society*. We are indebted to Dr. R. S. Cahn, of the Chemical Society, for consultation about nomenclature.

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[1] Szwarc, M., *J. Chem. Phys.*, **16**, 128 (1948).
[2] Baker, W., Banks, R., Lyon, D. R., and Mann, F. G., *J. Chem. Soc.*, 27 (1945).

Spectrographic Examination of Chromatographic Columns

In the determination of metallic traces, insufficient attention has been paid either to the advantages of direct spectrography of chromatographic columns, or to the chromatographic behaviour of organic metal complexes, although in the latter sphere the use of oxine[1] and of violuric acid[2] has been reported.

Working with alumina as adsorbent and using dithizone complexes, we have established the position of a number of metals in the undeveloped column by cutting it into a series of short sections and examining these sections spectrographically. We have concentrated initially on the estimation of very small traces of cadmium, and the procedure outlined below for this element illustrates the general technique.

The sample solution (normally acid) is made ammoniacal in the presence of ammonium citrate, and is then completely extracted with a solution of dithizone in carbon tetrachloride. A column of activated alumina (Spences 'H' 100–200 mesh) 5 cm. long and 4 mm. in diameter is prepared, and the extract after washing and filtration is poured through, using suction. The first centimetre, which normally weighs between 100 and 130 mgm., is cut out and retained for the estimation of cadmium.

Spectrographic examination is carried out using a carrier-distillation technique similar to that described by Scribner and Mullin[3], but employing silver chloride[4] as carrier and arsenic as internal standard. The anode cup-charge of 40 mgm. is subjected to a direct-current arc of 10 amp., and duplicated spectra are photographed on a Kodak *B*10 plate, using a Hilger large quartz spectrograph. The ratio of strengths of cadmium 2288·0 A. and arsenic 2288·1 A. is determined and compared with that of standard samples photographed on the same plate. Quantities of cadmium between 0·1 and 0·5 μgm. can conveniently be determined by the method with a standard deviation of 10 per cent. This represents concentrations of between 0·02 and 0·1 parts per million on a 5-gm. sample; this sample weight can, of course, be varied to enable a wider range of concentrations to be covered. With special care, a quantity of cadmium as small as one-fiftieth of a microgram can be detected qualitatively.

It is planned to extend the procedure to include other elements amenable to chromatographic treatment, using dithizone or other reagents.

The permission of the Chief Scientist, Ministry of Supply, to make this communication is acknowledged.

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A. P. Seyfang
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July 8.

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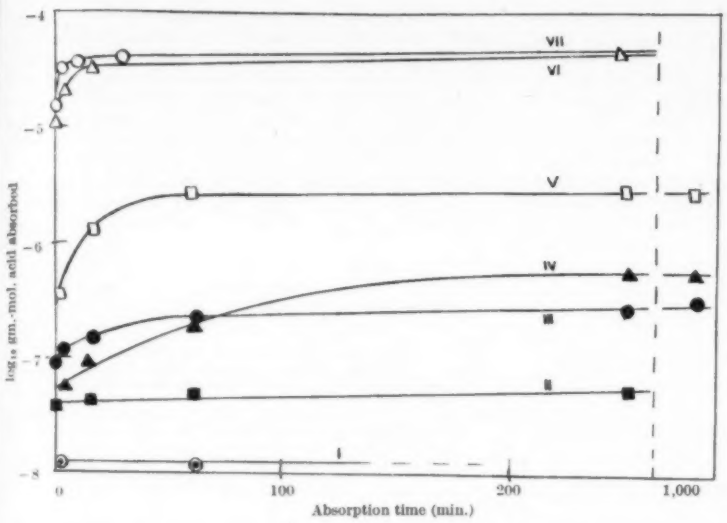
[4] Harrison and Kent, U.S. Atomic Energy Research Report *MDDC* 1581 (declassified).

Diffusion in Ion-Exchange Media

During an investigation into the behaviour of solutions of direct cotton dyes of the aromatic azo sodium sulphonate type on ion-exchange materials, it was found that selective penetration of the resin structure occurs.

Solutions containing the derived sulphonic acids of a number of dyes of relatively high molecular weight were obtained (together with the inorganic acids derived from the salts present in the commercial products) by treatment with the cation-exchange 'Zeokarb 215' operating on the hydrogen cycle. These solutions, when passed through the acid-absorbing, anion-exchange resin 'De-Acidite B', gave an effluent containing the pure dye acid with, apparently, little absorption of the dye on the basic resin. This was unexpected as the dye acids were thought to be highly dissociated in solution, and this was afterwards confirmed by electrometric titration.

Cernescu[1] has shown that the effective capacity of the natural zeolite, chabazite, for the substituted ammonium ion decreases with increasing ionic radii. Kunin and Winters[2] have also shown a similar de-



crease using a sulphonic acid-type cation-exchanger and aralkyl-ammonium ions. No comparable results for the anion-exchange reaction appear to have been recorded.

In the case of dyes, the cation-exchange process involves only the diffusion of sodium and hydrogen ions, whereas the acid absorption reaction requires the penetration of the resin by the much larger dye molecules (or dye anions). It seemed possible to postulate, therefore, that some of the dye molecules examined were too large to enter all of the structure of the resin. This hypothesis has been substantiated by studying the absorption of a number of aromatic sulphonic acids of different molecular dimensions. The results obtained using 12·5 ml. of 0·0028 *M* solutions and 1 gm. of air-dry resin at 20° C. are shown in the accompanying diagram. The equilibrium absorptions are given in the table, together with the approximate ionic dimensions.

I Diphenyl - 4 - (2 - azo - 1 - hydroxy - naphthalene - 3 : 6 - disulphonic acid) - 4′ - (2 - azo - 1 - hydroxy - naphthalene - 3 - sulphonic acid). Colour index No. 388.
II 3 : 3′ - Dimethoxydiphenyl - 4 : 4′ - bis - (2 - azo - 8 - amino - 1 - hydroxy-naphthalene-5 : 7-disulphonic acid). Colour index No. 518.
III Naphthalene - 1 - sulphonic acid - 4 - (1 - azo - 2 - hydroxy - naphthalene-6 : 8-disulphonic acid). Colour index No. 185.
IV 2 - Hydroxy - naphthalene - 6 : 8 - disulphonic acid - 1 - azobenzene. Colour index No. 27.
V 2 : 4-Dihydroxy-benzene-1-azobenzene-*p*-sulphonic acid.
VI Naphthalene-2-amino-1-sulphonic acid.
VII Sulphuric acid.

Compound No.	Equilibrium absorption (gm. mol. acid/gm. resin)	Per cent absorption of solute	Approximate largest dimension of ion (A.)
I	$0{\cdot}01 \times 10^{-4}$	0·03	30
II	$0{\cdot}05 \times 10^{-4}$	0·14	30
III	$0{\cdot}31 \times 10^{-4}$	0·9	20
IV	$0{\cdot}45 \times 10^{-4}$	1·3	15
V	$2{\cdot}2 \times 10^{-4}$	6·3	15
VI	33×10^{-4}	94	10
VII	35×10^{-4}	100	5

All the acids show an initial rapid absorption during the first minute, followed by a slower take-up to an equilibrium value which increases with decreasing molecular size. The large disazo dyes I and II show little increase after the initial rapid absorption, which suggests that this is reaction at the surface, followed, with the smaller molecules, by a slower diffusion into the bulk of the resin. The final equilibrium figure will be modified to some extent by the degree of sulphonation of individual molecules, but the selective diffusion effect must predominate since the more highly sulphonated molecules are less absorbed.

Some of the larger dyes in the form of their sodium salts are associated in solution, but it is not known whether they are equally associated in dilute solutions of their free acids in the absence of inorganic ions. However, since there exists a dynamic equilibrium between single dye molecules and aggregates, the equilibrium figures for the dye absorbed should not be invalidated by this aggregation.

It is thus possible to conclude that the microstructure of anion-exchange resin of the 'De-Acidite' type is such that it is physically impossible for large dye ions to enter and diffuse to all the points of exchange within the granule; as the molecular size of the dye ion is reduced, progressively more of the structure becomes available for absorption, until with simple aromatic sulphonic acids almost all exchange points react. This is consistent with a picture of the resin as an amorphous body containing a network of pores which may vary in size from 10 to 20 A. in diameter, through which all anions must diffuse into the interior of the granule before absorption on the basic exchange points.

The use of exchange resins in the purification and isolation of acid, direct and basic dyes is being investigated, and a complete account will be published elsewhere.

I wish to thank Dr. T. H. Morton for his interest and advice, and the directors of Courtaulds, Ltd., for permission to publish this communication.

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Oct. 13.

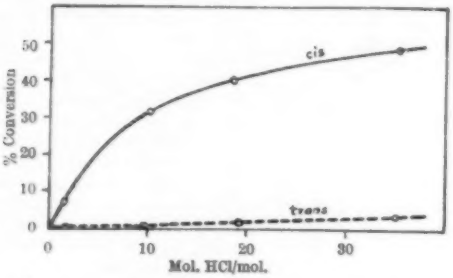
[1] Dissert. 661 Eidg. Tech. Hochschule Zurich (1933).
[2] Colloid Symp. U.S. Army Chem. Centre (1947).

Configuration of Alicyclic Amino-Alcohols

We have extended our investigations[1] on the acyl migration reaction N → O to acyl derivatives of diastereoisomeric alicyclic amino-alcohols[2], such as 2-amino-*cyclo*hexanol[3], with the view of establishing the relative steric positions[4] (that is, configuration) of hydroxyl and acylamido groups.

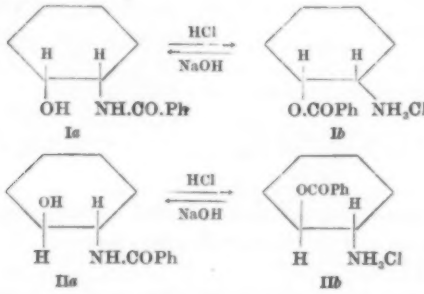
Cis- and *trans*-2-benzamido-*cyclo*hexanol were each treated separately with absolute alcoholic hydrogen chloride at room temperature. The amide, m.p. 189°, previously[5] considered to be II*a*, but recently suggested[6] to be I*a*, gave on action of 2 mol. of hydrochloric acid, O-benzoyl-2-amino-*cyclo*hexanol hydro-

chloride, m.p. 228°, in 9 per cent yield, besides 90 per cent of unchanged amide. Under identical conditions, 2-benzamido-*cyclo*hexanol, m.p. 174°—previously recorded[7] as the *cis* form, but recently postulated[8] to be II*a*—furnished the corresponding O-benzoyl-2-amino-*cyclo*hexanol hydrochloride, m.p. 284°, only to an extent of 0·1–0·2 per cent, while 98 per cent amide was recovered unchanged. Using hydrogen chloride in very great excess at room temperature, 50 per cent of hydrochloride, m.p. 228°, and 4·5 per cent of hydrochloride, m.p. 284°, respectively could be obtained (see graph).



Each amino-ester salt was re-arranged by alkalinization into the amide from which it was prepared; as an acyl shift, O → N never occurs with inversion[8]; consequently the benzoyl shift N → O took place in both cases with retention of configuration.

We interpret this discrepancy in the acyl migration N → O as follows. 2-Benzamido-*cyclo*hexanol, m.p. 189°, undergoing readily acyl migration, is of *cis* configuration (I*a*) as well as the corresponding amino-ester salt, m.p. 228° (I*b*), whereas its diastereoisomer, m.p. 174°, being far less spontaneously convertible into the amino-ester salt, m.p. 284°, possesses *trans*-configuration (II*a*). Our results are in accordance with those of McCasland *et al.*[6] obtained by a quite different way.



Nevertheless, at 100° each diastereoisomeric amide gave, with retention of configuration, the corresponding amino-ester salt, I*b* or II*b* respectively, with an approximate yield of 50 per cent[9]. This can be explained by the well-known flexibility of the *cyclo*hexane ring[10], so that substituents in the *trans* position can approach each other—due to rotation—to the extent required for the acyl migration to take place. The same factor may cause the originally *cis*-placed substituents to move apart. Obviously, an increase of temperature favours such transitions[11]. For similar steric reasons, both the *cis* and *trans* 1.2-*cyclo*hexandiols failed to increase the conductivity of boric acid or to form cyclic acetals[12].

The difference between the stereoisomeric benzamido-*cyclo*hexanols observed in the acyl migration reaction N → O *at room temperature* gives, in our opinion, evidence of their steric structure. Experimental details will be published elsewhere.

We are now extending our investigations to the configuration of diastereoisomeric amino-borneols containing a 'rigid' ring system[13] in order to control the general usefulness of our method for the determination of the configuration of alicyclic amino-alcohols.

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June 15.

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[2] Fodor, G., Lecture delivered at the Meeting of Hung. Engineers Union, Szeged, Dec. 12, 1948; summarized in *Acta Chem. Phys. Szeged*, **2**, 227 (1949).
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[4] Attempts to convert amino-*cyclo*hexanol into 1.2-*cyclo*hexandiol of known configuration were unsuccessful: Wilson, N. A. B., and Read, J., *J. Chem. Soc.*, 1270 (1935).
[5] English Patent 454,042 (1936).
[6] McCasland, G. E., *et al.*, *J. Amer. Chem. Soc.*, **71**, 638 (1949), found that benzamido-*cyclo*hexanol, m.p. 189°, can be prepared from its diastereoisomer by tosylation and subsequent detosylation in an analogous manner to the preparation of *cis*-acetyl-*cyclo*hexandiol-1.2 from the *trans* form. cf. Winstein, S., *et al.*, *J. Amer. Chem. Soc.*, **64**, 2796 (1942).
[7] Beilstein, **13**, 348, 4th edit.
[8] Welsh, L. H., *J. Amer. Chem. Soc.*, **69**, 128 (1947).
[9] Incomplete acyl migration was recorded in the case of *bis*-acyl-2-amino-phenol, leading to an equilibrium mixture, cf. le Rosen, A. L., *et al.*, *J. Amer. Chem. Soc.*, **70**, 2705 (1948).
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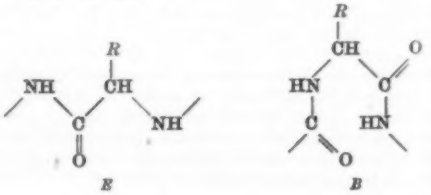
[11] Bier, G., *Experientia*, **2**, 82 (1946).
[12] Gilman, "Organic Chemistry", 109 (2nd edit.).
[13] Hückel, W., *loc. cit.*, 71.

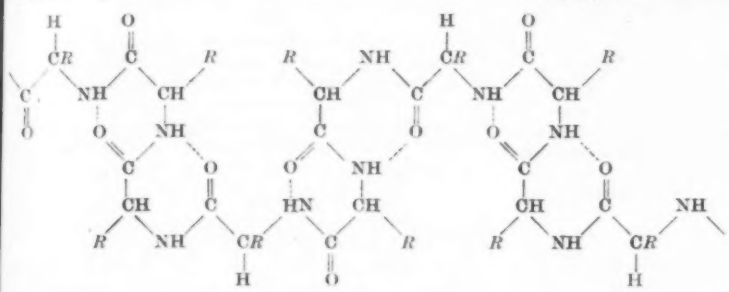
Stable Configurations of a Polypeptide Chain

In recent communications in *Nature*, Ambrose and his co-workers proposed a model for the molecular structure of α-keratin based on measurements with polarized infra-red rad
The same model has already been presente
of us (S. and M.) in 1947, based on the ene
sideration for the intramolecular rotation[2,4].

For some years we have studied the intramolecular rotation from our measurements of the Raman effect, infra-red absorption, dielectric constant, and electron diffraction, and have determined not only the stable configurations of simple molecules with internal rotation axes, but also those of complex ones[5]. We could thus explain, for example, the difference in the elastic properties between polyethylene and poly-*iso*butylene from the difference in their intramolecular potentials[6]. As to a polypeptide chain, two of us determined the following two stable forms of its structural unit by considering the energy change with intramolecular rotational angle about the C—C and the C—N axes:



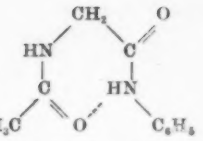
Let us denote these two forms by symbols *E* (extended form) and *B* (bent, or folded form). Then we can construct various stable configurations of the polypeptide chain by suitable combinations of these two forms, taking into account the fact that all the amino-acid residues of the chain are of the *L*-form: for example, *EEE* . . . corresponding to the extended chain of β-keratin proposed by Meyer and Mark[7], *BBB* . . . corresponding to the ribbon structure presented by Ambrose as well as by two of us, and *EBBEBB* . . . shown in the following diagram:



Furthermore, we can construct various ring structures such as $(EEEB)_3$, $(EBBB)_3$, $(EEEBBB)_3$, etc., characterized by the trigonal symmetry.

Various experimental results obtained for proteins can be explained quite reasonably from these molecular configurations. (*a*) The mechanical properties and the X-ray diagram of α-keratin can be explained by the *BBB* . . . configuration, as was pointed out by Ambrose and by us. This structure is also compatible with the result of the infra-red investigation made by Ambrose and his co-workers. (*b*) All these experimental results for α-keratin can also be explained satisfactorily by the *EBBEBB* . . . configuration, which is in some respects similar to that presented by Astbury in 1941 [8]. The intensity relation of the X-ray diagram of α-keratin and the same side-chain spacing observed for α- and β-keratins can be explained more reasonably by this configuration than by *BBB* . . . (*c*) From the tension-elongation diagram observed for wool[9], the energy difference between α- and β-keratins is calculated as 400 ~ 2,000 cal./mol.-residue, if the configuration of α-keratin is considered to correspond to *BBB* . . . or *EBBEBB* . . . (*d*) The trigonal symmetry often found for protein molecules can be understood from these ring configurations. (*e*) It depends upon the nature of an amino-acid residue whether this takes the *E*- or the *B*-form in the polypeptide chain. In other words, the nature of the side-chain determines the form of an amino-acid residue. The order of the various amino-acid residues in the polypeptide chain which has been often discussed seems, therefore, important in determining the characteristic molecular configuration of each protein. (*f*) The specificity of antibodies can be explained from the various combinations of *E*- and *B*-forms contained in the polypeptide chain. (*g*) Because of the small energy difference between *E*- and *B*-forms, the protein molecules tend to lose their characteristic configurations easily. This would explain the denaturation of proteins.

For the confirmation of the existence of the *B*-form we investigated a simple molecule capable of taking this form. If, for example, the molecule of acetylglycine anilide exists in the form:



it will show the N—H absorption characteristic of the intramolecular hydrogen bond. Our infra-red measurements were made on *N*-methyl acetamide, $CH_3CONHCH_3$, acetanilide, $CH_3CONHC_6H_5$, and acetylglycine anilide in carbon tetrachloride solution in the 3 μ region, where the absorption maximum at 2·9 μ can be assigned to the vibration of the N—H group in the free state and the maximum at 3·0 μ to that involved in hydrogen-bond formation. We found that acetylglycine anilide shows two bands, at 2·9 μ and at 3·0 μ, of almost the same intensity at a concentration (0·0002 mol./litre, 60° C.) at which *N*-methyl acetamide and acetanilide show absorption almost only at 2·9 μ and hence give practically no evidence of an intermolecular hydrogen bond. We have, therefore, to conclude that acetylglycine anilide forms an intramolecular hydrogen bond denoted by the dotted line of the figure shown above. This would be evidence for the existence of the *B*-form of the molecule of acetylglycine anilide, and hence also for certain amino-acid residues contained in the polypeptide chain.

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[5] For the summary of this work, see, for example, Mizushima, S., Morino, Y., Watanabe, I., Simanouti, T., and Yamaguchi, S., *J. Chem. Phys.*, **17**, 591 (1949).
[6] Mizushima, S., and Simanouti, S., *J. Amer. Chem. Soc.*, **71**, 1320 (1949).
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Some More Lower Limits of Half-Lives for α-Decay

Recently a powerful method for the determination of α-ray half-lives has been described[1,2,3]. The method consists essentially in counting the α-ray tracks produced in a photographic emulsion by the decaying nuclei. The nuclei are introduced into the plate by immersion into a solution of the element under investigation. Ilford *C*2 Nuclear Research plates are suitable.

A few additional elements have been examined for α-activity. The experimental details were the same as before[2,3]. Neutral solutions ($pH \sim 7$) could be used in all cases. The experimental results, together with the half-lives derived by means of the 'track count equation', are collected in the accompanying table. For the penetration factors (ratio between concentration in the emulsion and in the impregnating solution) the conservative values of 3, and in case of the (more concentrated) solutions of cæsium and praseodymium of 2·5 and 2, respectively, have been used on the basis of tests with radioactive ions[2]. Tracks due to members of the radioactive series have not been included in the count. As pointed out before[2], α-rays from long-lived isotopes of medium-heavy elements could in any event not have energies comparable to those of the rays from the radioactive series. On the low-energy side, it is thought that tracks containing at least about four silver grains each generally could not have escaped notice; this track-length corresponds to about 35 per cent of the track-length produced by α-particles from samarium.

Element	Salt used	Concentration (% element)	Time of exposure (days)	Tracks per field of view ($\sim 4 \times 10^{-7}$ c.c.)	Half-life (years $\times 10^{15}$)
Tl	K_2TlF_6	0·25	60	<0·001	>4
Zn	nitrate	0·35	60	<0·001	>4
Sr	lactate	0·3	60	<0·001	>3
Cs	carbonate	0·8	60	<0·001	>4
Pr	acetate	1	60	<0·001	>4
Th	(value from literature; for comparison)				0·000014
Sm + Nd	nitrate	see below	7	see below	see below

The absence of an unknown group of α-rays in salts of neodymium and samarium (elements 60 and 62) has been taken as evidence against the natural existence of an α-active isotope of element 61[3]. A weak point in the evidence was that the history of the two preparations was not precisely known. The preparations might have been subjected to treatment which would remove element 61. Plates were therefore impregnated with a solution of an intermediate fraction in the neodymium–samarium separation during the industrial fractionation by crystallization of the rare earths extracted from monazite (see last line of the table).

A crude estimate of the degree of enrichment of element 61 during fractionation may be obtained as follows. For simplicity, it is assumed that fractionation consists only of one step. The enrichment factors between 60 and 61, and between 61 and 62, are assumed to be equal (γ). Then, if the mole fractions in the mineral are [60], [61] and [62], and in the enriched system [60]′, [61]′ and [62]′,

$$[61]' = \gamma \frac{[61]}{[60]} [60]' \qquad (1)$$

and

$$[62]' = \gamma \frac{[62]}{[61]} [61]'. \qquad (2)$$

Dividing (1) by (2),

$$[61]' = [61] \left([60]' [62]' / [60] [62] \right)^{1/2}. \qquad (3)$$

Since $[61] \ll 1$ and $[61]' \ll 1$, (4a, b)

we have

$$[60] = 1 - [62] \text{ and } [60]' = 1 - [62]' \qquad (5\,a, b)$$

and

$$[61]' = [61] \left([62]' (1 - [62]') / [62] (1 - [62]) \right)^{1/2}. \qquad (6)$$

In the minerals of the rare earths the abundance of neodymium is about three times the abundance of samarium[4]. In the fraction used here the abundance ratio was 42 : 58 (communication from Treibacher Chemische Werke). Hence

$$[61]' = [61] \left(\frac{[0{\cdot}58 \times 0{\cdot}42]}{[0{\cdot}25 \times 0{\cdot}75]} \right)^{1/2} \sim 1{\cdot}15\,[61] \qquad (7)$$

Consequently, the ratio 61 : Sm should have changed by a factor $1{\cdot}15 \times \frac{0{\cdot}25}{0{\cdot}58}$, or $\sim 0{\cdot}5$.

Now in a volume of emulsion containing 100 tracks from samarium, not a single track belonging to an unknown group was found experimentally. Assuming that no further appreciable fractionation of rare earths occurs during penetration into the emulsion, it is concluded that the α-activity a_{61} of element 61 in minerals is

$$a_{61} < 0{\cdot}01\, a_{Sm}/0{\cdot}5 \qquad (8)$$

if a_{Sm} is the activity of samarium. This improved value supersedes the value given previously[3].

Our thanks are due to Prof. K. Przibram for his interest in our work, and to Dr. O. Smetana of Treibacher Chemische Werke for the gift of preparations of the rare earths.

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Influence of a Magnetic Field on the Conductivity of Thin Metallic Films

A NEW type of magneto-resistance effect in metals has recently been discovered by D. K. C. MacDonald[1]. It occurs in thin wires at low temperatures under conditions such that the diameter of the specimen, the free path of the conduction electrons and the radius of the circular orbits of the electrons in a magnetic field are all of comparable orders of magnitude. MacDonald has given a qualitative theoretical discussion of the effects; the object of the present note is to point out that a corresponding effect exists, and that a detailed mathematical treatment is possible, for the particular case of a thin film placed in a magnetic field which is normal to the surface of the film. The calculation is based on a free electron model, so that there is no magneto-resistance effect in the bulk metal[2], and it consists of a generalization of the method given by Fuchs[3] for the case of zero magnetic field. Assuming that the electrons suffer diffuse reflexion at the surface of the film, the main results are found to be as follows.

Let a be the thickness of film, l the free path, r the radius of circular orbits, and put $\varkappa = a/l$, $\beta = a/r$ and $s = \varkappa + i\beta$. (In the notation of ref. 2, $\beta/\varkappa = H\sigma_0/nec$.) Then the ratio of the resistivity $1/\sigma$ to that of the bulk metal $1/\sigma_0$ is given by

$$\sigma_0/\sigma = \mathscr{R} \{\varphi(s)\}/\varkappa, \qquad (1)$$

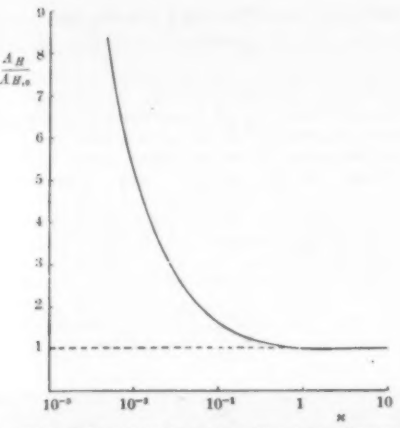

Fig. 1. Hall coefficient of thin metallic films (in small magnetic fields) divided by Hall coefficient of bulk metal (diffuse surface scattering is assumed)

and the ratio of the Hall coefficient A_H to that of the bulk metal $A_{H,\infty}$ is

$$A_H/A_{H,\infty} = \mathscr{I}\{\varphi(s)\}/\beta, \qquad (2)$$

where

$$\frac{1}{\varphi(s)} = \frac{1}{s} - \frac{3}{8s^2} + \frac{3}{2s^2}\int_1^\infty \left(\frac{1}{x^3} - \frac{1}{x^5}\right) e^{-sx}\,dx, \qquad (3)$$

and $\mathscr{R}$ and $\mathscr{I}$ denote the real and imaginary parts respectively.

Equations (1) and (2) may be used to discuss the magnetic effects for all values of the free path and of the magnetic field.

In the limit of zero magnetic field ($\beta \to 0$), equation (1) reduces to equation (18) of Fuchs's paper, while equation (2) leads to a corresponding formula for the Hall coefficient which is shown graphically in Fig. 1. Thus the Hall effect in thin films shows an increase analogous to the well-known increase of the electrical resistivity.

The field variation of σ_0/σ predicted by equation (1) is complicated and shows oscillations, but it may be shown that the resistance *increases* initially with β provided that $\varkappa < 1{\cdot}6$ approximately. For very strong fields the resistance tends to the asymptotic value

$$(\sigma_0/\sigma)_{\beta=\infty} = 1 + (3/8\varkappa); \qquad (4)$$

this value is slightly less than the resistance in zero field for $\varkappa > 0{\cdot}1$ approximately, but exceeds the zero field value for smaller values of $\varkappa$. The ratio $A_H/A_{H,\infty}$, on the other hand, decreases steadily with β and tends to unity as β tends to infinity.

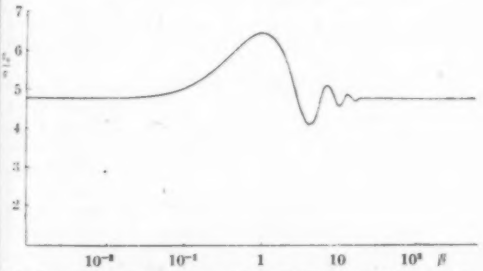

Fig. 2. Variation of resistance of thin metallic films with magnetic field normal to surface of film (diffuse scattering is assumed). $\varkappa = 1/10$

Fig. 2 shows σ_0/σ as a function of β for a typical value of $\varkappa$. The theoretical behaviour is in qualitative agreement with MacDonald's measurements on a sodium wire placed in a transverse field, if it is assumed that the strongest fields used by him were insufficient to reach the first minimum predicted by the theory; but our results cannot, of course, be expected to apply in detail to the case of a wire.

A full account of the theory, including a discussion of the case of partially elastic surface scattering, will be published in due course.

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Influence of a Magnetic Field on the Size-Variation of Electrical Conductivity

Following upon Dr. Sondheimer's letter above, we feel it may be of interest to mention some theoretical work that we have undertaken on this problem. Dr. Sondheimer's work appears of peculiar interest since, in the case of a thin plate in a transverse magnetic field perpendicular to the plane of the film, one is not led to expect *any* variation of conductivity on a simple mean free path concept such as used by Thomson[1] and Lovell[2] in their size-effect analyses. We were therefore ourselves led to consider the problem of the application of a transverse magnetic field in the *plane* of the film, since elementary consideration of the electron trajectories in this case readily indicates a mechanism for decrease of the resistance.

This analysis is now formally complete and will be published in detail elsewhere. The general expressions do not lend themselves readily to numerical computation, but for small magnetic fields ($\beta = a/r \ll 1$; $\eta = l/r \ll 1$; $\eta^2 \ll \beta$, where a is the film thickness, l is the mean free path, and r is the radius of the free electron orbits) we find for the conductivity σ:

$$\frac{\sigma}{\sigma_0} \doteq 1 - \frac{3}{8\varkappa}\Big[(1-4\eta^2)\Big\{1 - 4\int_0^{\pi/2}\{\exp(-\varkappa/\cos x)\}\sin^2 x\cos x\,dx\Big\} + \frac{21}{8}\eta^2 + 6\beta^2\int_0^{\pi/2}\{\exp(-\varkappa/\cos x)\}(\sin^2 x/\cos x)\,dx + \frac{3}{2}\beta^2\int_0^{\pi/2}\{\exp(-\varkappa/\cos x)\}(\sin^4 x/\cos^2 x)\,dx + 16\,\beta\eta\int_0^{\pi/2}\{\exp(-\varkappa/\cos)\}\sin^3 x dx\Big], \qquad (1)$$

where $\varkappa = a/l$. The integrals may be expressed in terms of the Ei function.

For larger fields such that $a \gg 2r$, we have without approximation :

$$\frac{\sigma}{\sigma_0} = 1 - \frac{3}{8\varkappa} \cdot \frac{1}{1+4\eta^2} \left[1 + \frac{3}{2} \cdot \frac{\eta^2}{1+\eta^2} \{1 - \exp(-2\pi/\eta)\} + \frac{3}{2} \frac{\eta^2(13\eta^2+12)}{(\eta^2+4)(9\eta^2+4)} \cdot \{1 + \exp(-2\pi/\eta)\}\right], \quad (2)$$

where it is clear that for $H \to \infty$ ($\eta \to \infty$) the conductivity tends to the bulk value, σ_0.

In deriving these expressions, we have assumed that the scattering at the boundary is inelastic. We have also assumed that the Hall coefficient is the same as for bulk metal. The error due to the latter approximation vanishes for large fields and is small for small fields.

(*Note added in proof.* Further investigation shows that, for small H, the Hall field approaches the bulk value exponentially as we recede from an edge. We have still to determine the precise variation of conductivity which then results.)

These expressions give qualitative agreement with the observations on capillary-wires reported previously[2]. Thus, for example, equation (1) shows that the resistance rises initially (and therefore shows a maximum) for $\varkappa = 1$ (and smaller values of $\varkappa$) but decreases initially (showing no maximum, consequently) for $\varkappa = 2$ (and greater values of $\varkappa$), the 'inversion point' occurring at $\varkappa \doteq 1{\cdot}9$. This result may be compared with the fact that a 30-μ diameter capillary specimen ($l \doteq 45\,\mu$ at 4·2° K.) shows a distinctive maximum (see ref. 3), whereas, in fact, no maximum could be detected in a specimen of diameter $\sim 66\,\mu$ at the same temperature.

On the other hand, our expressions for the thin plate are found to exaggerate considerably the rate of rise and fall of resistance observed in capillary-wire specimens. This behaviour has been confirmed by simple calculations using a constant free path. In fact, the result appears quite reasonable, since in a wire the overall constriction of free paths due to the geometry is more severe, particularly in fine specimens, than in a flat plate. It is hoped shortly to be able to test these results using a thin sodium plate.

It may be worth mentioning here that we have rigorously extended Fuchs's calculation[4] of the simple size-effect in a thin plate to the case of a rectangular wire. For 'thick' specimens one finds that the effect of the two pairs of faces is merely additive. For 'thin' specimens calculations for a *square* wire give results in close agreement with those obtained by Andrew[5] for a cylinder based on a constant free-path analysis. The case of a square wire provides, in fact, a very close approximation throughout to the cylindrical wire of equal cross-section, and we are at present examining the effect of superimposing a longitudinal magnetic field; a crude mean free path analysis is complete. The analysis of a transverse field, which could then be directly compared with the available results on wire specimens, is also under consideration.

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A Phenomenon Observed during the Freezing of a Non-homogeneous Aqueous Solution

In the course of experiments which revealed previously unreported electrical phenomena accompanying the freezing of water[1], another striking, if somewhat unrelated, phenomenon was observed.

Small samples of very dilute aqueous solutions were frozen in a platinum-plated copper cup by placing the cup in a shallow mercury pool on the end of a copper bar maintained at about − 15° C. Electrical measurements were made by making contact with the surface of the water with a fine platinum wire connected to the probe of an electrometer. While freezing a solution of silver nitrate (approximately 10^{-4} normal) the startling effect illustrated by the accompanying photograph was observed.

To afford a local increase in concentration of the solute a small grain (pin-head size) of silver nitrate was placed in the liquid just ahead of the ice-water interface. A few seconds after the region in which the grain was dropped had solidified, a milky-white spot appeared in the ice. About 10 sec. later a white filament began to grow radially inward from this spot at the rate of about 1 cm./min.

The foremost end of the filament remained at all times in the solid phase of the system and continued to grow towards the centre of the sample after freezing was complete. In some cases the initial direction of growth of the filament was not radially inward; in these cases, however, the direction changed to radially inward before the filament was more than a few millimetres in length. Two grains were used in the experiment shown in the photograph better to illustrate the direction of growth.

The explanation offered for the foregoing phenomenon follows. The liquid in the region of the added grain of silver nitrate becomes saturated and its freezing point is raised well above that of the surrounding dilute solution. A region of concentrated solution is therefore enveloped by ice. As freezing then progresses toward the centre of this region, silver nitrate is precipitated, causing the milky-white spot described before. As freezing continues toward the centre, the increased volume of the solid phase develops pressure on the remaining liquid. This pressure is relieved as the milky-white liquid oozes

along the grain boundaries or tiny cracks of the ice toward the centre of the sample.

The phenomenon is not believed to be related to the electrical effects observed during the freezing of aqueous solutions. Certainly no significant changes in the potentials recorded accompanied the addition of the grain of silver nitrate or the subsequent events. The phenomenon does seem of interest, however, in the study of freezing processes and the structure of ice.

The work was done and is continuing under the sponsorship of the U.S. Army Signal Corps.

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Radiation and Sensation of Pain

It is generally supposed that the only significant reaction produced by absorption, in the tissues, of infra-red radiation—and it applies practically to the radiation from electric lamps—is to cause a rise in temperature of the tissues, there being no attendant chemical effect such as accompanies ultra-violet irradiation. Thus, whereas for ultra-violet irradiation the energy absorption in a single treatment is of the order of 10 calories, in the case of infra-red radiation it is more than 10,000 times larger.

Because of the comparatively elementary nature of the reaction involved, the relation between the intensity (I) of incident radiation and the time (T) necessary to cause the 'sensation of pain' in the portion of the body exposed to radiation, is likely (in a rough way) to admit of a simple physical explanation. The problem is also connected, of course, with the determination of the tolerance limits for radiation treatment. Recently, Wolff and Hardy[1], and Bigelow *et al.*[2], and also Drake Seager and Lax[3], have described quantitative measurements on the (T, I) relation: Bigelow's work relates to the forehead, and Drake Seager and Lax's to the arm. The source of radiation in the former case was an incandescent lamp and in the latter case a gas-fired furnace. The range of I covered was 5–25 pyron (pyron is calories per sq. cm. per minute). It is interesting to note that the experimental results, within the limits of deviations observed, can be described by the relation

$$T = \frac{5{\cdot}0 \times 10^2}{I^2}, \qquad (1)$$

where T is in seconds and the intensity of radiation I is in pyron.

The $T - I^2$ relation has a simple theoretical basis. For a semi-infinite solid (initially at temperature $\theta = 0$) which is subjected to a constant heat flux I at the plane $\chi = 0$, the temperature at $\chi = 0$, at any time T, is given by

$$\theta = \frac{2I}{K}\left(\frac{KT}{\pi S\rho}\right)^{1/2}, \qquad (2)$$

where K is the thermal conductivity of the solid, S the specific heat and ρ its density[4]. It is reasonable to assume that the sensation of pain is initiated when the tissue temperature rises by some fixed value θ_0; we thus have from (2)

$$T = \frac{\pi S\rho K}{4}\,\frac{\theta_0^2}{I^2}, \qquad (3)$$

which is the $T - I^2$ law. Further, a comparison with equation (1), and taking for ($S\rho K$) a value of about 2×10^{-3}, we have $\theta_0 \approx 9{\cdot}4°$ C., which is not unreasonable. (Since the above was written, we have seen a paper by Lloyd-Smith and Mendelssohn[5], where it has been found experimentally that for the excitation of the sensation of pain a temperature rise of 15° F. of the surface of the skin is necessary. The agreement of this result with the value of θ_0 given above is interesting, though the rather close agreement is probably a coincidence.)

It would be of interest to determine the skin temperature simultaneously with $T - I^2$ measurements. It is proposed to do this, and also to extend the range of the $T - I^2$ relation.

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Band-Spectrum of Barium Oxide

The introduction of barium salts to flames or arcs leads, in presence of oxygen, to the production of a characteristic band-spectrum attributed to BaO. Mecke and Guillery[1] derived a band-head equation. Mahanti[2] gave a new vibrational analysis and also made a rotational analysis. From this the spectrum was shown to arise from a $^1\Sigma - {}^1\Sigma$ transition with $B'_e = 0{\cdot}30995$, $B''_e = 0{\cdot}36440$ cm.$^{-1}$ and $r''_e = 1{\cdot}787 \times 10^{-8}$ cm. On checking Mahanti's data, several discrepancies became apparent. Thus some of the plots of $2\nu_0$ against J^2, [$2\nu_0 \simeq R(J-1) + P(J) - 2(B' - B'')\,J^2$], show anomalous changes of slope, some of the combination differences agree rather poorly, and the usual graphical method for determination of B, namely, by plotting $\Delta_2 F(J)/(J + \frac{1}{2})$ against $(J + \frac{1}{2})^2$, gives for B'_2 another value than that quoted by Mahanti. These facts were disclosed by James[3], who, from some relatively low-dispersion plates, was able to suggest an alternative rotational analysis with $B'' \simeq 0{\cdot}31$, $B' \simeq 0{\cdot}26$ cm.$^{-1}$.

We therefore considered it desirable to carry out a new rotational analysis. As source we used an acetylene – air flame running at a pressure of about four atmospheres of air, fed with an aqueous solution of barium chloride. The spectrograms were taken in the first order of a 21-ft. Wood concave grating (165,000 lines) having a dispersion of about 1·2 A./mm.

Eleven bands have been analysed, namely, the 5,0, 4,0, 3,0, 3,1, 2,0, 2,1, 1,1, 1,2, 0,2, 0,3 and 0,4 bands. The vibrational analysis of Mahanti has been shown to be correct; but his rotational analysis is in error. The rotational constants derived in the present work are as follows:

$B'_3 = 0{\cdot}2524$ cm.$^{-1}$ $B'_4 = 0{\cdot}3062$
$B'_4 = 0{\cdot}2534$ $B'_5 = 0{\cdot}3076$
$B'_5 = 0{\cdot}2544$ $B'_6 = 0{\cdot}3091$
$B'_6 = 0{\cdot}2556$ $B'_7 = 0{\cdot}3105$
$B'_7 = 0{\cdot}2565$ $B'_8 = 0{\cdot}3119$
$D'_e = 28 \times 10^{-6}$ $D'_e = 25 \times 10^{-6}$
$r'_e = 2{\cdot}134 \times 10^{-8}$ cm. $r'_e = 1{\cdot}940 \times 10^{-8}$ cm.

In the upper vibrational levels several perturbations have been found, which for $v' = 1$, 2 and 3 are checked by observations on two bands for each v'-level. This fact gives strong evidence for the correctness of our analysis. A more detailed paper will appear later.

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Diffraction Associated with Defocusing

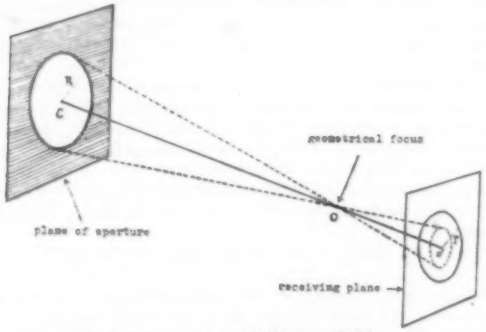
THE diffraction patterns near the focus in a plane perpendicular to the axis of a spherical wave front which passes through a circular aperture have been investigated by various authors[1–7]. The most complete treatment of this problem appears to be due to Lommel[7], who derived expressions for the wave-disturbance in receiving planes other than the geometrical focal plane, and thus extended Airy's classical results[1].

In some applications, particularly in those concerned with the performance of astronomical refracting telescopes, it is desirable not only to know the diffraction patterns but also to obtain a convenient expression for the proportion of the total illumination falling outside a given circle with the axial point as centre. In the geometrical focal plane this is given by the well-known formula:

$$J_0^2(v) + J_1^2(v), \qquad (1)$$

due to Rayleigh[8].

Here $v = \frac{2\pi R}{\lambda f} r$; R denotes the aperture radius, r the radius of the circle, f the distance CO between the plane of the aperture and the geometrical focus, and λ is the wave-length.



$CO = f$; $OO' = \Delta f$; $v = \frac{2\pi R}{\lambda f} r$; $u = \frac{2\pi R^2}{\lambda f^2} \Delta f$

Starting from Lommel's formulæ, I have recently been able to generalize Rayleigh's result to the case when the receiving plane does not coincide with the geometrical focal plane, and obtain the following expressions for the fraction L of the total illumination falling outside a circle of radius r about the axial point, situated in a plane parallel to the aperture stop and distant $f + \Delta f$ from it:

$$L = L(u,v) = 1 - \left(\frac{v}{u}\right)^2 \left[1 + \sum_{n=0}^{\infty} \frac{(-1)^n}{2n+1} \left(\frac{v}{u}\right)^{2n} P_{2n}(v)\right]$$

$$+ \frac{4}{u}\left[Y_1(u,v) \cos\tfrac{1}{2}\left(u + \frac{v^2}{u}\right) + Y_2(u,v) \sin\tfrac{1}{2}\left(u + \frac{v^2}{u}\right)\right]$$

$$\text{when } \left|\frac{v}{u}\right| \leqslant 1 \qquad (2a)$$

$$= \sum_{n=0}^{\infty} \frac{(-1)^n}{2n+1} \left(\frac{u}{v}\right)^{2n} P_{2n}(v) \qquad \text{when } \left|\frac{v}{u}\right| \geqslant 1 \qquad (2b)$$

Here $$u = \frac{2\pi R^2}{\lambda f^2} \Delta f,$$

so that $u = \pm v$ gives the edge of the geometrical shadow.

Y_1 and Y_2 are two of the functions

$$Y_n(u,v) = \sum_{s=0}^{\infty} (-1)^s (n+2s) \left(\frac{v}{u}\right)^{n+2s} J_{n+2s}(v)$$

which have recently been introduced by Hopkins[5], and the P_{2n} are certain polynomials involving Bessel functions, defined by the equation:

$$P(v) = \sum_{s=0}^{2n} (-1)^s [J_s(v)\, J_{2n-s}(v) + J_{s+1}(v)\, J_{2n+1-s}(v)]$$

When $u = 0$, (2b) reduces to

$$L(0,v) = P_0(v) = J_0^2(v) + J_1^2(v)$$

in agreement with (1).

When $u = \pm v$, (2a) and (2b) reduce to

$$L(v\,v) = J_0(v) \cos v + J_1(v) \sin v$$

giving the fraction of illumination falling outside the purely geometrical confusion disk.

Equations (2a) and (2b) make it possible to calculate the light scattered by diffraction from stellar images formed by refracting telescope objectives, taking into consideration the presence of the secondary spectrum. The results also have a bearing on the general question of 'distant diffracted light'. These questions, and the derivation of (2a) and (2b), will be discussed in more detail elsewhere.

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Thermal Expansion of Ionospheric Layer and Temporary Morning Disappearance of Radio Signals

It is usually assumed that under normal conditions of the ionosphere, if a radio signal is received after ground sunrise, it is likely to maintain its strength until absorption in the ionospheric region becomes pronounced during the day. It has often been found, however, during our observations of fading, that the reception of signals on shorter wave-bands completely ceases for about an hour or more after ground sunrise. The present communication is to show that thermal expansion of the F_2-region may be sufficient to overcome the enhancement of ionization caused by increase in solar altitude with advance of the day. To quote a few typical examples out of many occasions, the signals transmitted from All India Radio, Delhi, on December 28, 1946, on 19-m. band were received in Benares (678 km.) until 0711 hr. I.S.T., when they disappeared for about an hour. A similar disappearance of signal on the same wave-band was observed on April 11, 1947, at 0750 hr. I.S.T., lasting for about two hours.

The temporary disappearance of the signal in the morning hours may be attributed to thermal expansion of the F_2-region[1,2], as shown in Tables 1 and 2 below.

Table 1. December 28, 1946; 19-m. band, Delhi

Time (I.S.T.)	Layer condition	Required electronic density (elec./c.c.)	Observed electronic density (elec./c.c.)
0700 hr. Before disappearance	Thin	$1{\cdot}41 \times 10^6$	$1{\cdot}60 \times 10^6$
0711 hr. Disappearance	Thick (thermal expansion)	$1{\cdot}93 \times 10^6$	$1{\cdot}63 \times 10^6$
0830 hr. Reappearance	,,	$1{\cdot}91 \times 10^6$	$1{\cdot}92 \times 10^6$

Table 2. April 11, 1947; 19-m. band, Delhi

Time (I.S.T.)	Layer condition	Required electronic density (elec./c.c.)	Observed electronic density (elec./c.c.)
0720 hr. Before disappearance	Thin	$1{\cdot}23 \times 10^6$	$1{\cdot}34 \times 10^6$
0750 hr. Disappearance	Thick (thermal expansion)	$1{\cdot}76 \times 10^6$	$1{\cdot}36 \times 10^6$
1000 hr. Reappearance	,,	$1{\cdot}70 \times 10^6$	$1{\cdot}71 \times 10^6$

The observed electronic densities shown in the last column of the tables indicate continuous increase of ionization as the day advances. Col. 3 of the above tables, however, shows the calculated electronic densities required for reception of signal, taking into consideration the normal expansion of thickness of the layer[3,4]. Comparison of the values of electronic densities which are given in columns 3 and 4 indicates the inadequacy of electrons in the ionospheric region during the periods of cessation of signals. The slight decrease in the value of required electronic density at the time of reappearance is due to alteration in the height of the layer. It may be mentioned that all such cases of disappearance of signals were preceded by periodic patterns of fading, as expected by Appleton and Beynon[5], and as such they were not due to scattered signals which are likely to be received within the skip distance[6,7].

The calculations for Tables 1 and 2 have been made with the help of ionospheric data and charts supplied to us by the research staff of All India Radio, Delhi, and the National Physical Laboratory, Teddington, to whom our thanks are due.

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Simplified Calculation, suitable for Routine Use, of a Linear Regression

There are many experimental procedures which involve the simultaneous observation of two variables, one of which is dependent upon the other. If the relationship between these variables is linear, then it is possible, by spacing the intervals equally with reference to the independent variable, to calculate the slope of the line, using the method of least squares, with the minimum of arithmetical computation.

A typical procedure of this kind is the estimation of the enzyme cholinesterase, employing the Warburg technique. The method is applicable only if the rate of production of carbon dioxide is linear, and the raw data should be inspected to ensure that the condition of linearity is sensibly satisfied. The slope of the straight line which best fits the data can be determined with the greatest ease if manometer readings are taken at four equally spaced intervals, for example, 15, 30, 45 and 60 min. after tipping.

The slope of the line of best fit is given generally by

$$\frac{\Sigma\ (\Delta t\ \Delta m)}{\Sigma\ (\Delta t^2)},$$

where Δt is deviation of each time observation from the mean and Δm is deviation of each manometer reading from the mean.

Taking the values above, the mean time is 37·5 min. and the deviations are −22·5, −7·5, +7·5 and +22·5 min. respectively. To facilitate calculation, the unit of time in this series may be chosen as 7·5 min., in which case the deviations are −3, −1, +1 and +3.

Let A_{15}, A_{30}, A_{45} and A_{60} be the manometer readings at the times indicated, and let $\overline{A}$ be the mean.

$$\Sigma(\Delta t.\Delta m) = -3(A_{15}-\overline{A}) - (A_{30}-\overline{A}) + (A_{45}-\overline{A}) + 3(A_{60}-\overline{A})$$
$$= 3(A_{60}-A_{15}) + (A_{45}-A_{30}).$$

On this scale $\Sigma(\Delta t^2)$, too, lends itself to simplifying the calculation, for $(-3)^2 + (-1)^2 + (+1)^2 + (+3)^2 = 20$.

Hence the slope required is, quite simply,

$$\frac{1}{20}\left\{\begin{matrix}3 \times \text{extreme range of} \\ \text{manometer readings}\end{matrix}\right\} \pm \left\{\begin{matrix}\text{intermediate range of} \\ \text{manometer readings}\end{matrix}\right\}.$$

In order to calculate cholinesterase activity as volume of carbon dioxide per N minutes, all that is

required is to multiply this slope by N expressed in the special time-scale adopted (for example, 30 min. is, in this instance, 4 units), and the usual manometer constant.

This method of calculation is, of course, applicable with appropriate modifications to any process in which the intervals of the independent variable can be equally spaced.

A point of interest emerging from the above is that whereas it is considered that four points are a minimum for determining the slope of the line, the number of observations should always be even. By using an odd number, the mean and median are the same, Δt of the median reading is zero, and consequently the reading is unnecessary, as it does not enter into the calculation.

Many statistical procedures are so cumbersome in practice that their routine use becomes too time-consuming, despite their undoubted value. Therefore any simplification in computation such as is presented here reduces the application of these methods to a process which can be very easily applied to routine work, with a consequent marked increase in precision.

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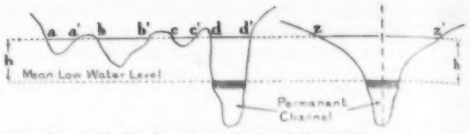
Some Characteristics of the White Nile and Sobat Flood Plains

The recent Egyptian proposals for the control of the Nile[1] have led me to make a detailed study of certain features of the White Nile and River Sobat. I have shown[2] that on the White Nile the total width of the water surface varies approximately as the square of its height above the normal low level all the way along the river; and that this relationship is on the average fairly constant for long stretches, in spite of large local variations. Thus for some purposes the river bed, with its complicated and varying channels, may be 'idealized' into a simple and symmetrical trough with banks which are approximately parabolic in profile (see diagram). This 'idealized trough' makes it comparatively simple to estimate the surface area and also (by integration) the contained volume at any stage of the flood for any length of the river, by using a mean of comparatively few cross-sections.

In this way detailed analyses have been made of sixteen floods on the White Nile between Malakal and Renk, at which point discharges have been measured regularly. It was possible from these analyses to obtain a figure for average evaporation depth in the dry season which agreed well with values assumed previously (average of Piche tube readings at Malakal and Renk over several years multiplied by 0·5); to estimate the mean depth of water absorbed by the flood plain during the rising stage; and by comparing the observed and computed discharge differences at the two points to make for each flood an estimate of the amount of water which had flowed into the river from tributaries entering between them. This last item was confirmed in years when it was exceptional by qualitative records of their flow.

The River Sobat enters the White Nile just above Malakal and is mainly responsible for its fluctuations.



Actual and idealized cross-sections of the White Nile Valley. The vertical scale is exaggerated about 200 times. ($zz' = aa' + bb' + cc' + dd'$ for all values of h)

Unfortunately, almost no cross-sections of the Sobat valley have been measured; but an estimate of its average cross-section between the discharge sites at Sobat Head and Hillet Doleib was made by reversing the form of analysis described above, and applying it to the rising stage of the Sobat flood. It was assumed, as was found on the White Nile, that rainfall and evaporation virtually cancelled out; that the mean absorption depth was the same; and that the profile of the banks of the idealized trough was also approximately parabolic. The constant of this parabola could then be obtained in terms of the measured discharges at the ends of the trough and of the average maximum rise all the way along it, which was obtained from gauge readings. Values of the constant derived in this way from five separate floods had a mean value of 28·5, with a range of 6·2 and a probable error of the mean of just less than unity, or about 3 per cent.

The 1929 air survey of these rivers (which contains no contours) shows on both a feature marked as "permanent marsh", and on the White Nile this was found to correspond closely to the maximum area inundated by a flood of average height. Using the parabolic constant already obtained, I therefore computed the area flooded by an average rise of the Sobat (the mean of thirty years) and found that it agreed within 15 per cent with the area of the corresponding feature as scaled off the air survey maps.

There seem, therefore, to be grounds for supposing that on the Sobat the bed formation is similar to that shown on the White Nile by the measured cross-sections. Moreover, this method of 'idealization', and the analysis based on it, may be applicable to similar rivers elsewhere in the world. If so, it would seem to be possible either to analyse their floods in considerable detail even if comparatively few cross-sections of their valleys exist; or to obtain an idea of the average cross-section of a reach by consideration of the gauge readings along it and of the discharges measured at its ends.

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Oxidation of the Coagulation Factors

The results of our previous work point to the fact that oxidation hinders the clotting of blood, whereas reduction accelerates it[1]. It could be inferred from other experiments that respiration, by means of its regulation of oxygen tension, has an important effect on the coagulability of the circulating blood[2].

In the present work we investigated the effect of oxidation of certain coagulation factors on their coagulant efficiency. Experiments were carried out in which separated clotting components and whole plasma were exposed to the action of molecular oxygen, which was passed through them in a flotation vessel. During these experiments, samples were

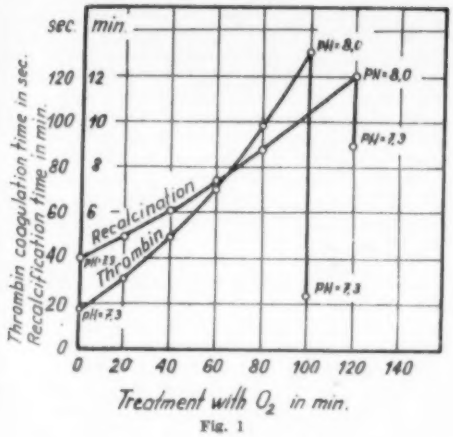

Fig. 1

drawn off at regular intervals and were tested by appropriate clotting systems to determine their remaining activity. The clotting systems consisted of 0·1 ml. amounts of thrombokinase, prothrombin, calcium chloride ($M/25$), and fibrinogen (0·6 per cent), or 0·1 ml. amounts of thrombin, and plasma (containing 0·2 per cent sodium oxalate). In each system the coagulation-time was recorded with a stop-watch, and the temperature was kept constant. The times recorded were taken to indicate changes in the factors after exposure to oxygen.

The results obtained were those expected. Fig. 1 shows that thrombin and thrombokinase are gradually inactivated during exposure to oxygen, the residual activity lying on a smooth curve when plotted against time of exposure. Once activity is lost, it cannot be restored by subsequent reduction. In contrast to the effect of this treatment on thrombin and thrombokinase, prothrombin and fibrinogen show no change of activity when exposed to the same conditions, and presumably, therefore, are not susceptible to oxidation (see Fig. 1). In these experiments the pH of materials examined was controlled by a potentiometer, and was kept constant with a precision of 1/100 (6·70).

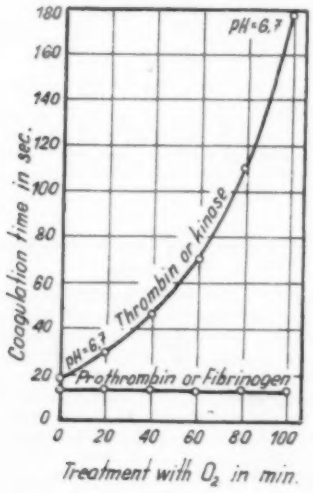

Fig. 2

The influence of oxygen on plasma must be dealt with separately (Fig. 2). The coagulability of plasma by thrombin was progressively reduced by exposure to oxygen, and yields a curve similar to that given in Fig. 1. It was found, however, by means of observations of pH, that the plasma became progressively alkaline as a result of oxidation (7·3–8). If the pH was adjusted to its original value, the coagulability of the plasma was restored almost to normal, but never quite reached it. The coagulation of the treated plasma by recalcification was also reduced by exposure to oxygen, and this reduction is less reversible by restoration of the pH. It appears, therefore, that both the thrombin fibrinogen reaction, and also the generation of thrombin in plasma following recalcification, is inhibited both by pH changes and by oxidation. The former is reversible, the latter apparently irreversible. The decrease in the coagulability of recalcified plasma, following exposure to oxygen and the adjustment of pH, suggests that its plasmakinase may be inhibited; but it is clearly less susceptible to oxidation than is tissue thrombokinase. As is known, thrombin and thrombokinase preparations lose their activity during prolonged storage, and it is probable that this loss is a result of oxidation. It can be presumed also that the clotting components used in these experiments (thrombin and thrombokinase prepared by Hoffmann La Roche, and brain thrombokinase prepared in the laboratory) contained substances necessary to the activation of molecular oxygen. The susceptibility of these components to the action of oxygen probably depends, therefore, on these substances, which are in turn influenced by such factors as pH and the colloidal and ionic conditions of the mixtures employed. Experiments on this aspect of the problem are being carried out. Similar observations have not been found in the literature available to us, with the exception of a note by Owren[3], recording that his thrombokinase preparation was inactivated when oxygen was passed through it.

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Nature of the Circulating Thyroid Hormone

Taurog and Chaikoff[1] have presented strong evidence in support of the view that in the normal animal the circulating thyroid hormone consists of thyroxine loosely attached to plasma protein. They observed in rat plasma that the protein-bound iodine labelled with radioactive iodine (I^{131}) followed thyroxine carrier quantitatively when the latter was crystallized repeatedly, or when it was distributed between two immiscible solvents. In the experiments to be described, confirmation of this work has been obtained by the use of paper partition chromatography[2].

In each experiment three male hooded rats weighing between 260 gm. and 290 gm. were used. The animals had been maintained since weaning on a stock diet containing 0·2 μgm. of iodine per gm. of

diet. Each animal received, by intraperitoneal injection, 80 microcuries of iodine-131 as carrier-free sodium iodide in 2 ml. of normal saline. Twenty-four to forty-eight hours following the injection, blood was removed by heart puncture from each of the three animals and the samples pooled. The plasma was prepared and 1-ml. portions were taken for the determination of total radioactive iodine and protein-bound radioactive iodine. The remainder of the plasma was extracted twice with three volumes of redistilled *n*.butanol. A portion of the butanol extract was shaken twice with one volume of 4*N* sodium hydroxide – 5 per cent sodium carbonate reagent. Radioactivity determinations were carried out on the butanol extract of plasma and on the alkali-extracted butanol.

Five experiments were carried out. The period between injection of the radioactive iodide and the removal of blood from the animals was 24 hours in three experiments and 48 hours in two experiments. The results of the radioactivity determinations are shown in the accompanying table. Each result represents the analysis on the pooled blood from three rats.

Determination	Per cent of total plasma I^{131}				
	24-hr. experiment			48-hr. experiment	
	1	2	3	1	2
Protein-bound I^{131}	50	75	34	76	77
Butanol-extractable I^{131}	60	65	60	75	70
Butanol extractable I^{131} but not re-extractable with 4*N* NaOH – 5% Na_2CO_3	31	58	26	63	59

In each experiment samples of the butanol extract of plasma and the alkali-extracted butanol were run on one-dimensional phenol paper chromatograms and on one-dimensional chromatograms in which a 1 : 1 (v/v) mixture of *n*.butanol and *n*.amyl alcohol was the mobile phase and 2*N* ammonia the stationary phase[3]. S milar samples were run on phenol/*n*.butanol : *n*.amyl alcohol two-dimensional paper chromatograms. Duplicates of the two butanol extracts with added sodium iodide and thyroxine were treated in like fashion. From each of the papers a radioautograph was prepared by placing the chromatogram, with a sheet of 'Cellophane' intervening, in contact with an Ilford Industrial *B* X-ray film for fourteen days. The chromatograms containing carrier were finally developed to show up the iodide and the thyroxine. Silver nitrate was used for the former and ninhydrin for the latter.

Two spots appeared on the radioautographs prepared from the papers on which the butanol extract of plasma had been chromatographed. The first spot had the same R_F value as sodium iodide, the second spot the same R_F value as thyroxine. When the radioautographs of the chromatograms which contained added iodide and thyroxine were superimposed on the developed papers, the first spot on the film was found to correspond exactly in position, shape and size with the iodide spot on the paper. The second spot on the film could be matched in similar fashion with the thyroxine spot on the paper. Only one spot appeared on the radioautographs prepared from the papers on which the alkali-extracted butanol had been chromatographed. This spot had the same R_F value as thyroxine. Superposition of the radioautographs of the chromatograms containing carrier thyroxine on the ninhydrin-developed papers showed that the spot on the film corresponded exactly in position, shape and size with the thyroxine spot on the paper. It would thus appear that the original butanol extract of the rat plasma contained two compounds labelled with radioactive iodine, namely, inorganic iodide and thyroxine, while the alkali-extracted butanol contained only labelled thyroxine. It can be seen from the table that in the 48-hour experiments this radioactive thyroxine fraction contained approximately 60 per cent of the total plasma radioactive iodine.

It was necessary to determine whether the dose of radioactive iodine (80 microcuries) had interfered with normal thyroid function. Jones[4] has shown with varying dosage-levels of iodine-131 in rats that thyroxine continues to be formed so long as the acinar cells of the thyroid remain intact. In the present experiments, histological sections were prepared from the thyroid gland of each animal. In no case was any abnormality of cellular structure observed. It was also necessary to show that the appearance of radioactive iodine in thyroxine did not occur by the process of exchange during the preparation of the chromatograms. This was achieved by running a butanol extract of normal rat plasma containing added radioactive iodide and non-radioactive thyroxine through the chromatography and radioautography procedures. Under these conditions no radioactivity appeared in the thyroxine. Finally, the possible loss of iodine from thyroxine during the preparation of the chromatograms was investigated. A butanol extract of normal rat plasma containing added thyroxine labelled with iodine-131 (kindly supplied by Dr. Lester Smith of Glaxo Laboratories, Greenford, Middlesex) was run through the chromatography and radioautography procedures. Under these conditions no radioactivity was detected except in the thyroxine.

The results presented above indicate that a large portion of the iodine of rat plasma is in the form of thyroxine, and they lend further support to the view that the circulating thyroid hormone is indeed thyroxine and not thyroglobulin or a thyroxine-containing peptide.

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Resting Potential and Ion Movements in the Frog Skin

IT is a well-established fact that sodium and potassium ions are treated differently by the majority of animal cells. During recent years it has become evident that active extrusion of sodium is taking place in muscle, nerve, etc.[1,2,3,4,5]; on the other hand, the distribution of potassium is often considered to be the result of Donnan equilibria, so that no specific transport mechanism for this ion is regarded as necessary.

This point of view is mostly the result, however, of lack of evidence to the contrary. In few cases

has it been demonstrated unambiguously that potassium ions inside the cells are in true equilibrium with those outside, the main difficulty being that the activity coefficient of potassium in living protoplasm can only be guessed.

The uncertainty as to the activity coefficient can be circumvented if identical solutions are applied on both sides of the membrane, since the electric potential then provides the only force acting on passive ions. This condition cannot be fulfilled for a single cell membrane, but it can be shown[6] that for a free ion the following equation holds independent of the structure of the membrane, even if it consists of several cell layers:

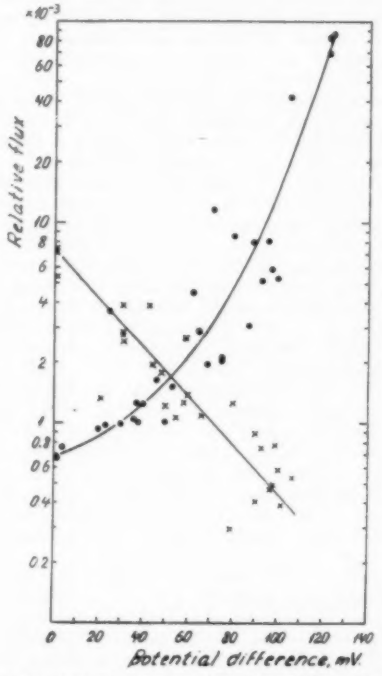
$$\frac{M_1}{M_2} = \frac{a_1}{a_2},$$

where M_1 is the flux of the ion in one direction and M_2 the simultaneous flux of the same ion in the opposite direction, a_1 and a_2 are the electrochemical activities of the ion in solutions 1 and 2, respectively. The flux (the amount passing through unit area in unit time) is determined by tracer experiments. If the ion concentration is the same on both sides of the membrane, we have for a monovalent ion at room temperature $\log \frac{M_1}{M_2} = \frac{\text{P.D.}}{58}$, where P.D. measured in mV. stands for the potential difference across the membrane. The expression thus provides a basis for checking whether an ion species passes through a membrane in the free state or (partly) in complex form. The formula suggests the use of two different tracer isotopes of the same element for the simultaneous determination of influx and outflux through a membrane.

We have applied sodium-22, half-life 3 yr. (kindly given to us by Dr. R. D. Evans, Massachusetts Institute of Technology, Cambridge, Mass.), and sodium-24, half-life 14·8 hr., to isolated living frog skin and measured M_1/M_2 as a function of the resting potential. The experimental arrangement was that used previously[5]. The results are given in the accompanying table. It is seen that even at the highest P.D. values observed, the influx of sodium ions is higher than the outflux. The enormous discrepancy between the values found and those calculated for M_1/M_2 shows that sodium passes in mainly in complex form (active transport) which is in accordance with previous results[5].

	μmol./cm.², h		P.D. in mV. (mean)	M_{in}/M_{out}	
	in	out		found	calc.
Ringer solution on both sides	1·87	0·1	60	18·7	0·09
	0·4	0·24	50	1·7	0·14
	0·6	0·05	70	12	0·06
	0·6	0·07	35	8·6	0·25
Half-Ringer solution on outside	1·0	0·1	45	10	0·08
	0·3	0·13	60	2	0·045
	0·14	0·07	70	20	0·03
	0·7	0·28	95	2·5	0·12

Measurements of the flux ratio have also been carried out with radioactive potassium. Since only one tracer isotope of potassium was available, influx and outflux were determined in parallel experiments. The potassium concentration was about 3·5 m.mol. per litre. The results from ten independent experiments are shown in the accompanying graph. It is seen that the higher the potential (the more positive the inside relative to the outside) the higher the outflux and the lower the influx. At 100 mV. a rough estimate gives $M_1/M_2 = 30$; $\log 30 = 1{\cdot}48$ against $100/58 = 1{\cdot}7$. This agrees reasonably well with the assumption of an entirely passive behaviour of the potassium ion. At lower P.D. values, however, a discrepancy appears between theory and experimental results. At *c.* 50 mV., influx and outflux are equal, whereas the P.D. requires that $M_{out}/M_{in} = 7$. At still lower potentials, the influx appears to be higher than the outflux, that is, an active transport of potassium inwards seems to take place.



The relative flux[4] of potassium ions through frog skin as a function of the resting potential. Ordinates: ×, influx; ●, outflux, on a logarithmic scale; abscissæ: potential difference in mV.

A natural explanation is that the mechanism transporting sodium inwards does not distinguish strictly between sodium and potassium. With increasing P.D., back diffusion of the cations rises; but that of potassium does so relatively more than that of sodium, thereby, so to speak, freeing sodium from contaminant potassium by electrodialysis. Obviously, this is only a working hypothesis. A more thorough study is required to decide whether potassium is transported by the same mechanism as is sodium.

Both types of experiments will be described in greater detail elsewhere.

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Squash Preparations of Living Root-Tip Cells

THE cells of plant root tips cannot be observed satisfactorily in squash preparations without removal of the intercellular cement. This is normally accomplished by the Feulgen hydrolysis, namely, by hydrolysis in *N* hydrochloric acid for a suitable period at 60° C. More recently, some authors have treated fixed root tips with pectic enzymes[1,2,3]. It was thought that it might be possible to separate the living cells with a pectinase complex and so be able to study mitosis and the sites of nucleic acid in living cells, and also the effects of fixation and of other treatments. Experiments were made to investigate this possibility.

Root tips of *Vicia faba* were used. The enzyme preparation was provided by Dr. R. G. Tomkins, of the Ditton Laboratory, East Malling, and is prepared as follows. *Penicillium digitatum* is grown on bran; the culture is then dried and an aqueous extract is made by mixing one part of the dried material with three or four parts of distilled water. The mixture is well shaken, allowed to stand for one hour, and filtered. The apical four to five millimetres of a root tip is excised, well washed by agitation in distilled water, and placed in the strong solution of the enzyme for twenty-four hours. It is removed, again washed in distilled water and put into a freshly prepared enzyme solution diluted to one-fifth of its original strength. After twenty-four hours the second cycle of washing and enzyme treatment is repeated. The root tips may then be teased and the cells separated.

Since the living cells do not resemble normal Feulgen preparations, it was necessary, in order to verify the normality of such cells, to fix and stain them in acetic carmine and, if required, follow this with a Feulgen stain. Normal mitotic figures were then seen.

After separation of the living cells, following enzyme treatment, it is possible to float the coverslip off in Ringer's solution and to keep the cells as a suspension in this solution in a small specimen tube. The use of Ringer's solution is indicated by its osmotic properties and lack of nutrient for growth of micro-organisms, for no attempt has been made to attain an aseptic technique.

Samples of such a suspension of cells, stained with acetic carmine, suggested that after maceration the cells complete the mitotic cycle in which they were at the time of maceration. At first the number of mitotically active cells declines to zero. This might be a shock effect, since afterwards mitosis reappears and the frequency of divisions increases. Mitotic figures have been observed four days after maceration.

These living, isolated cells do not resemble the cells separated by Feulgen hydrolysis; but they appear to be exactly similar to the intact cells of an untreated root teased mechanically. They also resemble the cells of root tips fixed by Newcomer's method[4]. They differ from fixed and Feulgen hydrolysed preparations mainly in the presence of many mitochondria which obscure other structures.

It is believed that the enzyme solution attacks the intercellular cement and, by thus weakening the tissues along intercellular cleavage lines, causes the cells to separate when teased with needles followed by gentle tapping on a coverslip placed on the tissue. If the enzyme treatment has been insufficient, the mechanical treatment bursts the cells owing to the lack of cleavage lines.

The main fault of this method, as developed at present, is the danger of growth of micro-organisms. This is minimized by washing the tips thoroughly in water and by frequent changes to fresh enzyme solutions. If the tips can be grown aseptically, this trouble may be overcome.

I wish to express my gratitude to Dr. D. G. Catcheside for his advice and guidance in this work. I also wish to acknowledge the encouragement and advice given me by Prof. J. T. Randall and Dr. Honor B. Fell, of the Medical Research Council Biophysics Unit, King's College, London.

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New British Records of Two Rare Deep-Sea Fishes: *Oxynotus paradoxus* Frade and *Aphanopus carbo* Lowe

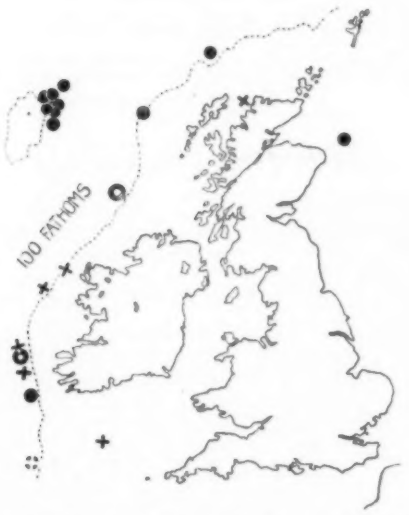
THROUGH the courtesy of Mr. W. Wilson of Milford Haven and of the staff of the Lowestoft Fisheries Laboratory we have received three deep-sea fishes taken by the *Richard Crofts* in 330 fathoms at a point 250 miles W. by S. of St. Ann's Head on March 10.

The first species is the small shark *Oxynotus paradoxus* Frade[1], represented by a female of total length 895 mm. (Specimen IX). The type was described from the coast of Morocco, and another was obtained in the Gulf of Gascony; the remaining known records are all British and the specimens are in the British Museum except where otherwise stated:

I	April	1931	♀	70 miles W.N.W. of Fastnet, S.W. Ireland[2].
II	April	1931	♀	Black Rock, N.W. Ireland, at 160 fathoms[3]. (Three specimens, of which only one reached the B.M.)
III	March	1933	♀	Scourie Bank, 5 miles south of Handa, North Minch, N.W. Scotland. (Royal Scottish Museum, Edinburgh, No. 1933.23.)
IV	Feb.	1934	♂	Messrs. Barrow, Billingsgate Market. Possibly from Irish waters, via Milford Haven.
V	July	1934	♂	Irish Atlantic Slope, 53° 40′ N., 11° 15′ W., at 145 fathoms[4].
VI	May	1935	♀	Labidee Bank, 50° 30′ N., 8° 20′ W., in 60-65 fathoms. (National Museum of Wales, Cardiff, No. 35.527.1).
VII	April	1938	♀	52° 30′ N., 12° 30′ W., in 290 fathoms. (National Museum of Wales, No. 38.293.1.)
VIII	March	1945	♀	"Trawled in deep water, landed at Milford Haven." (Probably from Irish Atlantic Slope.)

The general concentration of these records along the edge of the Atlantic Slope during the late spring, apparently unrelated to any seasonal localization of the fishing fleets, led us to consider the possibility of an inshore migration at this time of year. The six specimens available to us have been examined for food-contents; but all were practically empty and the few particles present so well digested and finely divided as to afford no evidence. The flattened belly and tiny ventral mouth with prominent lips and specialized dentition suggest a bottom-feeding habit, and that breeding rather than feeding would, therefore, be a more likely migration

stimulus. Of the females, Nos. I, VIII and IX were immature, but No. II seemed recently to have bred; the oviducts were greatly distended and contained many vascular filaments as in other viviparous Squalidæ. Of the males, No. IV was ripening and No. V was spent. The high proportion of females so far obtained (7 : 2) agrees with Steven's[4] discussion of sex-proportions and migrations in other Elasmobranchs.



×: Distribution of *Oxynotus paradoxus* in British waters. ●, ○: Distribution of *Aphanopus carbo* in British waters. Open circles show approximate positions of stations worked by the *George Bligh* and *Florence Brierley* in 1927

The second species is *Aphanopus carbo* Lowe[5] (Percomorphi–Trichiuridæ), represented by two female specimens of 935 and 1,105 mm. total length. The type was described from Madeira, where there is an important long-line fishery for this locally abundant species, and elsewhere there are scanty records from Portugal[6], the Faeroes[7], Denmark Strait[8], and Iceland (Lucas, *in lit.*). If *Aphanopus schmidti* Saemundsson proves to be a synonym of this species, as appears likely, many records will be added for Iceland, and the range extended to north Norway. Other known records are:

Sept. 1913	♀	23 miles N.E. of Rockall, in 180 fathoms[9]. (Kelvingrove Museum, Glasgow, No. '13–93.)
April 1923	♀	W. of St. Kilda in 150 fathoms. (Two specimens, of which only one reached the B.M.)
March 1924	♀	"Off Fastnet and Bull Rock, 100–260 fathoms." (B.M.)

A considerable number of further records have been collected at the Torry Marine Laboratory, Aberdeen. Seven of these refer to the area within a radius of 25–50 miles N.E. to E.S.E. of Rockall, in depths between 200 and 400 fathoms, during the months of May, June and August 1926, October 1928 and May 1930. Records of sex are available for only three specimens: two females and a male. A catch of twenty individuals 33 miles N.E. of Rockall on May 29, 1926, is noteworthy. The remaining British records from the Torry Laboratory are:

July 1926		"West coast, Scotland."
Nov. 1933	♂	27 miles N.E. of Buchanness. (First report for the North Sea.)
April 1936		50 miles N.N.W. of the Butt of Lewis. (Two specimens.)

For two records in June 1925 no locality data are available.

In addition to the above, Hickling[10] reports the occurrence of *Aphanopus* along the Atlantic Slope during the spring of 1927. Dr. Hickling has kindly amplified the details given in his paper to give the following:

Feb. 1927	"Latitude about 52° N., longitude corresponding to 460 fathoms." Fish taken on vertical long-lines by the *George Bligh* at least 30 fathoms above the bottom.
April–May 1927	"Roughly north-west of Tory Island", at 200–220 fathoms. "At that time the fish might be seen anywhere along the edge of the deep water." Trawled by the *Florence Brierley*. Feeding on *Gadus poutassou*.

Aphanopus is evidently present about Rockall from May to October and probably also for the rest of the year. Elsewhere there is again a suggestion of a movement towards the Continental Shelf in late spring. We have examined the ovaries of the four specimens at the British Museum and find them nowhere near spawning. Hickling[11] has suggested that the spawning migration of the blue whiting (*Gadus poutassou* Risso) to the west of Wyville Thompson Ridge at the beginning of April is responsible for a feeding concentration of hake. The larger of our two new specimens of *Aphanopus carbo* contained well-digested remains of *Gadus poutassou* in addition to remains of a Myctophid and a squid, and there is a general agreement between the records of *Aphanopus* and the breeding-season and distribution of *Gadus poutassou* as described by Schmidt[12]. A feeding migration may therefore be suspected in this case also. Saemundsson[13] found *A. schmidti* more abundant about Vestmanneyjar (Iceland) at 250–350 metres during June and July, while Cuvier and Valenciennes[14] have observed that the related deep-sea Trichiurid *Lepidopus caudatus* (Euphrasen) approaches the shores in April and May.

Results of further investigations on these two species will be published elsewhere; in the meantime we shall be grateful for details of any new specimens.

We wish to thank Drs. S. M. K. Henderson, Colin Matheson and A. C. Stephen for information on specimens under their care at Glasgow, Cardiff and Edinburgh respectively; Dr. C. E. Lucas for generously allowing us to use the records accumulated at the Torry Marine Laboratory; Dr. C. F. Hickling for discussion of his cited papers, and Dr. Ethelwynn Trewavas for reading this note.

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June 16.

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FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, November 28

BRITISH SOCIETY FOR THE HISTORY OF SCIENCE (in the Lecture Theatre, Science Museum, Exhibition Road, London, S.W.7), at 5 p.m.—Dr. F. J. North: "Sir H. T. De la Beche; his Contributions to the Advancement of Science, and the Circumstances in which they were Made"; Dr. Maria Rooseboom: "Leeuwenhoek, the Man; a Son of his Nation and his Time".

ROYAL GEOGRAPHICAL SOCIETY (at Kensington Gore, London, S.W.7), at 5.30 p.m.—"Australian Aborigines" (Sound film with commentary).

ROYAL INSTITUTE OF CHEMISTRY, LONDON AND SOUTH-EASTERN COUNTIES SECTION (joint meeting with the WOOLWICH POLYTECHNIC SCIENTIFIC SOCIETY, at Woolwich Polytechnic, London, S.E.18) at 7.30 p.m.—Dr. A. C. Monkhouse: "The Minor Constituents of Coal".

Tuesday, November 29

UNIVERSITY OF LONDON (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 1.15 p.m.—Mr. A. J. Arkell: "Excavating in the Sudan".*

INSTITUTION OF ELECTRICAL ENGINEERS, EDUCATION DISCUSSION CIRCLE (at Savoy Place, Victoria Embankment, London, W.C.2), at 6 p.m.—Discussion on "The Electron Theory Approach to Electromagnetism" (to be opened by Prof. J. Thompson).

SOCIETY OF PUBLIC ANALYSTS and other ANALYTICAL CHEMISTS, PHYSICAL METHODS GROUP (in the Chemistry Lecture Theatre, Imperial College of Science and Technology, Imperial Institute Road, London, S.W.7), at 6 p.m.—Dr. J. G. A. Griffiths: "The Mass Spectrometer, a Survey of its Applications in Analysis".

MANCHESTER GEOGRAPHICAL SOCIETY (at the Geographical Hall, 16 St. Mary's Parsonage, Manchester), at 6.30 p.m.—Mr. B. Varley: "People and Food Supply".

ROYAL ANTHROPOLOGICAL INSTITUTE (in the Physiology Theatre, University College, Gower Street, London, W.C.1), at 8 p.m.—Prof. Ernest Beaglehole: "Contemporary Maori Culture".

ROYAL SOCIETY OF MEDICINE (at 1 Wimpole Street, London, W.1), at 8.30 p.m.—Earl Russell, O.M., F.R.S.: "Can a Scientific Community be Stable?" (Lloyd Roberts Lecture).

Wednesday, November 30

CHEMICAL SOCIETY (at the Royal Institution, Albemarle Street, London, W.1), at 2.30 p.m. and 8 p.m.—Symposium on "Fluorine Chemistry" (arranged by Prof. H. J. Emeléus, F.R.S.).

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 2.30 p.m.—Anniversary Meeting.

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 2.30 p.m.—Prof. H. Moore: "Recent Advances in the Manufacture of Plate and Sheet Glass".

INSTITUTE OF WELDING (at the Institution of Civil Engineers, Great George Street, London, S.W.1), at 6 p.m.—Monsieur Henri M. Schnadt: "The Schnadt Impact Test".

CHEMICAL SOCIETY, SOUTH WALES SECTION (at University College, Cardiff), at 7 p.m.—Dr. G. Gee: "Some Recent Advances in the Physical Chemistry of High Polymers".

Tuesday, November 29—Wednesday, November 30

INSTITUTION OF GAS ENGINEERS (at the Institution of Mechanical Engineers, Storey's Gate, St. James's Park, London, S.W.1), at 10 a.m. each day.—Fifteenth Autumn Research Meeting.

Thursday, December 1

UNIVERSITY OF LONDON (at the Institute of Psychiatry, Maudsley Hospital, Denmark Hill, London, S.E.5), at 4.30 p.m.—Prof. W. E. Le Gros Clark, F.R.S.: "The Visual System".*

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 5.15 p.m.—Sir Harold Spencer Jones, F.R.S.: "The Atmospheres of the Planets".

CHEMICAL SOCIETY, SHEFFIELD SECTION (joint meeting with the UNIVERSITY CHEMICAL SOCIETY, in the Chemistry Lecture Theatre, The University, Sheffield), at 5.30 p.m.—Dr. W. A. Waters: "Some Oxidations involving Free Radicals".

BRITISH INSTITUTION OF RADIO ENGINEERS, SCOTTISH SECTION (in the Electrical Department, The University, Glasgow), at 6.30 p.m.—Mr. A. A. M. Turnbull: "Electronics in Industry".

CHEMICAL SOCIETY, NOTTINGHAM SECTION (joint meeting with the UNIVERSITY CHEMICAL SOCIETY, in the Lecture Theatre, Chemistry Department, The University, Nottingham), at 6.30 p.m.—Scientific Papers.

Friday, December 2

ASSOCIATION OF APPLIED BIOLOGISTS (at the Imperial College of Science and Technology, South Kensington, London, S.W.7), at 11.15 a.m.—Symposium on "Clover".*

PHYSICAL SOCIETY (in the Small Physics Lecture Theatre, Imperial College of Science and Technology, Imperial Institute Road, London, S.W.7), at 5 p.m.—Mr. M. Ryle: "Significance of Observation of Intense Radio-frequency Emission from the Sun" and "Evidence for the Stellar Origin of Cosmic Rays".

BEDSON CLUB (in Lecture Theatre 1, Chemistry Department, King's College, Newcastle-upon-Tyne), at 5.30 p.m.—Dr. W. H. Taylor: "Recent Work on Transitions in Solids" (75th Bedson Lecture).

INSTITUTE OF PHYSICS, INDUSTRIAL SPECTROSCOPY GROUP (at 47 Belgrave Square, London, S.W.1), at 5.30 p.m.—Dr. A. G. Gaydon: "Recent Developments in the Spectroscopic Study of Combustion Processes".

GEOLOGISTS' ASSOCIATION (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 6 p.m.—Dr. A. J. Bull: "Gravitational Sliding".

ROYAL STATISTICAL SOCIETY, LONDON GROUP of the INDUSTRIAL APPLICATIONS SECTION (at the E.L.M.A. Lighting Service Bureau, 2 Savoy Hill, London, W.C.2), at 6 p.m.—Mr. P. Eisenklam: "Factorial Designs in Engineering".

CHEMICAL SOCIETY, MANCHESTER SECTION (joint meeting with the ROYAL INSTITUTE OF CHEMISTRY and the SOCIETY OF CHEMICAL INDUSTRY, in the Lecture Theatre, Gas Showrooms, Town Hall Extension, Manchester), at 6.15 p.m.—Prof. M. G. Evans, F.R.S.: "Some Studies of Oxidation–Reduction Reactions".

Saturday, December 3

BRITISH MYCOLOGICAL SOCIETY (in the Department of Biology, Chelsea Polytechnic, Manresa Road, London, S.W.3), at 11.45 a.m.—Annual General Meeting.

LONDON COUNTY COUNCIL (at the Horniman Museum, London Road, Forest Hill, London, S.E.23), at 3.30 p.m.—Mr. Percy Edwards: "The Voices of British Wild Birds".*

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ENTOMOLOGIST, and a MYCOLOGIST, for work on the co-ordination of research and development on insecticides and fungicides—The Secretary, Agricultural Research Council, 6a Dean's Yard, London, S.W.1 (December 3).

LECTURER IN MATHEMATICS, a LECTURER IN METALLURGY, and a LECTURER IN BIOLOGY, at the Constantine Technical College—The Director of Education, Education Offices, Woodlands Road, Middlesbrough (December 3).

SCIENTIFIC TECHNOLOGIST in the Coal Survey Laboratory in Cardiff—The National Coal Board, Establishments (General) Branch, Hobart House, Grosvenor Place, London, S.W.1, quoting TT. 165 (December 5).

EXPERIMENTAL OFFICER (temporary) in the Road Research Laboratory, Middlesex, for abstracting scientific and technical literature dealing with roads (construction, traffic, safety and economics)—The Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting F.790/49BN (December 5).

PHYSICISTS or ELECTRICAL ENGINEERS (Experimental Officer class, unestablished) at Ministry of Supply Research Establishments in Southern England—The Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting A.273/49BN (December 9).

HEAD OF THE SCIENCE DEPARTMENT—The Secretary, London School of Printing and Kindred Trades, 41 Stamford Street, London, S.E.1 (December 10).

LECTURER IN THE DEPARTMENT OF ELECTRICAL ENGINEERING, University of Cape Town—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (December 10).

SENIOR LECTURER or LECTURER IN PHYSIOLOGY, and an ASSISTANT LECTURER IN PHYSIOLOGY—The Registrar, The University, Sheffield (December 10).

MATHEMATICIANS or MATHEMATICAL PHYSICISTS (Principal Scientific Officer or Senior Scientific Officer grade) at a Ministry of Supply Research and Development Establishment near London, to give guidance to engineering design groups on the mathematical aspects of their problems—The Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting A.279/49BN (December 12).

PRINCIPAL SCIENTIFIC OFFICERS and SENIOR SCIENTIFIC OFFICERS at a Ministry of Supply Establishment in Bucks, for research and development work on rocket motors using solid propellants—The Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting F.804/49BN (December 14).

CHEMIST or ENGINEER (Experimental Officer grade) in a Ministry of Supply Research and Development Establishment near London, for work on the design and use of electronic and other instruments required for the investigation of combustion and allied processes—The Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting F.805/49BN (December 17).

PRINCIPAL SCIENTIFIC OFFICERS at a Ministry of Supply Research and Development Establishment near London—MECHANICAL or CHEMICAL ENGINEER (Ref. F.223/49BN) for work on the design and development of rockets and associated problems, and a MECHANICAL or ELECTRICAL ENGINEER (Ref. C.208/49BN) for work on artillery equipments and associated engineering problems—The Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting the appropriate Ref. No. (December 19).

STATISTICIAN, to build up the Statistical Branch of the Department of Commerce and Industry, Sierra Leone, with particular reference to the provision of data relating to economic development—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1 (December 31).

BIOLOGIST IN THE DEPARTMENT OF GENERAL PHYSIOLOGY, to work on the physiology of marine organisms—The Secretary, Marine Biological Association, The Laboratory, Citadel Hill, Plymouth (January 15).

I.C.I. RESEARCH FELLOWSHIPS IN BIOCHEMISTRY, CHEMISTRY, ENGINEERING, PHARMACOLOGY or PHYSICS—The Secretary, The University, Sheffield (March 1).

MECHANICAL ENGINEER, for experimental investigation of stresses in motor vehicle components—The Director, Motor Industry Research Association, Great West Road, Brentford, Middx.

ENTOMOLOGIST (preferably a woman) with a wide general knowledge of entomology and a special interest in the bibliographical and information aspect of the subject—The Director, Commonwealth Institute of Entomology, 41 Queen's Gate, London, S.W.7.

CHEMIST AND BACTERIOLOGIST—The Managing Director, East Surrey Water Company, London Road, Redhill, Surrey.